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PART V

FEDERAL ENERGY ADMINISTRATION

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ENERGY CONSERVATION PROGRAM FOR APPLIANCES

Notice of Proposed Rulemaking and Public Hearing

FEDERAL ENERGY ADMINISTRATION

[10 CFR Part 430]

ENERGY CONSERVATION PROGRAM FOR APPLIANCES

Notice of Proposed Rulemaking and Public Hearing

AGENCY: Federal Energy Administration.

ACTION: Proposed rule.

SUMMARY: The Federal Energy Administration hereby proposes to amend its regulations in order to prescribe test procedures for vented home heating equipment under the Energy Policy and Conservation Act. The Act requires that standard methods for testing vented home heating equipment a class within the type "home heating equipment not including furnaces," be prescribed as part of the energy conservation program for appliances. The intended effect of this proposal is to implement the Act's requirements for the solicitation of public comments before the test procedures are prescribed. The Federal Energy Administration is hereby also scheduling a further public hearing on the proposed energy efficiency improvement target for home heating equipment, not including furnaces.

DATES: Comments by October 25, 1977, 4:30 p.m.; requests to speak by October 21, 1977, 4:30 p.m.; statements by November 1, 1977, 4:30 p.m.; hearing for proposed test procedures to be held on November 2, 1977, at 9:30 a.m., and for proposed energy efficiency improvement target on November 2, 1977, at 1:30 p.m.

ADDRESSES: Requests to speak at the hearings to: Executive Communications, Room 3317, Federal Energy Administration, Box OQ (for the proposed test procedures) or Box NU (for the proposed target), Washington, D.C. 20461. Oral Statements to: Regulations Management, Room 2214, Federal Energy Administration, 2000 M Street NW., Washington, D.C. 20461.

HEARINGS HELD AT: Federal Energy Administration, Room 2105, 2000 M Street NW., Washington, D.C. 20461.

FOR FURTHER INFORMATION CONTACT:

James A. Smith (Program Office), Old Post Office Building, Room 307, 12th and Pennsylvania Avenue NW., Washington, D.C. 20461 (202–566–4635).

Robert C. Gilette (Hearing Procedures), 2000 M Street NW., Room 222A, Washington, D.C. 20461 (202–566–5201).

Jim Merna (Media Relations), 12th and Pennsylvania Avenue NW., Room 3104, Washington, D.C. 20461 (202–566–9833).

Laurence J. Hyman (Office of the General Counsel), 12th and Pennsylvania Avenue NW., Room 7146, Washington, D.C. 20461 (202–566–9750).

SUPPLEMENTARY INFORMATION:

A. *Background.*

The Federal Energy Administration (FEA) proposes to amend Chapter II of title 10, Code of Federal Regulations, in order to prescribe test procedures for vented home heating equipment, a class within the product type "home heating equipment, not including furnaces," pursuant to section 323 (42 U.S.C. 6293) of the Energy Policy and Conservation Act (Act) (Pub. L. 94–163). The adoption of test procedures does not mean that actual testing must be conducted. The procedures merely establish standard methods for testing when testing is otherwise required by the Act itself or by regulations implementing other parts of the program. For example, the Federal Trade Commission (FTC) may require that all or part of the test procedure be conducted in exercising its appliance energy efficiency labeling authority regarding a particular appliance type.

By notice issued May 10, 1976 (41 FR 19977, May 14, 1976), FEA proposed to establish Part 430, entitled "Energy Conservation Program for Appliances," in Chapter II of Title 10 of the Code of Federal Regulations. That notice proposed a Subpart A to Part 430, containing general program provisions, and a Subpart C, containing proposed energy efficiency improvement targets. By notice issued July 22, 1976 (41 FR 31237, July 27, 1976), FEA proposed an amendment to proposed Part 430 to add a Subpart B which would contain the appliance test procedures required to be prescribed by section 323 of the Act. Subparts A and B were established by notice issued on May 24, 1977 (42 FR 36648, July 15, 1977) withdrawing the original proposal of Subpart C and reproposing a new Subpart C containing proposed energy efficiency improvement targets for the products listed in 1–10 of section 322(a) of the Act. Energy efficiency improvement targets for the products listed in 11 and 12 of section 322(a) were proposed by separate notice (42 FR 40701, August 11, 1977).

Proposed test procedures for each product listed in 1–10 of section 322(a) of the Act were published prior to the hearing on the proposed energy efficiency improvement target for each product with the exception of vented home heating equipment. Because FEA believes that reference to proposed test procedures can facilitate public comment on the proposed targets, FEA has, by recent FEDERAL REGISTER notice (42 FR 42361, August 23, 1977), extended the deadline for written comment on the improvement target for home heating equipment (not including furnaces) to October 25, 1977 and has announced the holding of an additional hearing. This hearing, to be held at the time and place specified above, supplements the hearing on the home heating equipment (not including furnaces) improvement target held on August 19, 1977.

The notice issued on May 24, 1977 included final test procedures for room air conditioners. By notice issued March 17, 1977 (42 FR 15423, March 22, 1977) FEA proposed test procedures for dishwashers. This notice also included certain program definitions which have not yet been finalized. Proposed test procedures for water heaters, television receivers, refrigerators and refrigerator-freezers, freezers and clothes dryers were issued on April 21, 1977 (42 FR 21576 et seq., April 27, 1977). Proposed test procedures for unvented home heating equipment were issued on May 4, 1977 (42 FR 23860, May 11, 1977), and proposed test procedures for automatic and semi-automatic clothes washers were issued on May 11, 1977 (42 FR 25329, May 17, 1977), including a determination that test procedures cannot be developed for any other class of clothes washers. Proposed test procedures for humidifiers and dehumidifiers were issued on May 25, 1977 (42 FR 27941, et seq., June 1, 1977). Proposed test procedures for central air conditioners were issued on June 7, 1977 (42 FR 30401, June 14, 1977), and were followed by proposed test procedures for conventional ranges, cooking tops and ovens, as well as microwave ovens, which were issued on June 9, 1977 (42 FR 30627, June 16, 1977). The latter notice included a determination to delay the publication of test procedures for any other class of the type "kitchen ranges and ovens." The proposed test procedures for furnaces were issued on July 28, 1977 (42 FR 40826, August 11, 1977). By this notice, FEA is proposing test procedures for vented home heating equipment.

Section 323(a)(2) of the Act requires FEA to direct the National Bureau of Standards (NBS) to develop, for specifically named types of covered products, test procedures for the determination of the estimated annual operating costs and at least one other useful measure of energy consumption which FEA determines is likely to assist consumers in making purchasing decisions. Pursuant to the Act, FEA directed NBS to develop test procedures for FEA's use in prescribing test procedures under the Act. As part of this undertaking, NBS evaluated existing test procedures for measuring energy consumption of vented home heating equipment.

Current testing and rating requirements for vented home heating equipment are described in a number of standards, including: American National Standards Institute (ANSI) Z21.48–1976 for gas fueled gravity and fan type floor furnaces; ANSI Z21.49–1975 for gas fueled gravity and fan type vented wall furnaces; Z21.11.1–1976 for gas fueled vented room direct vent wall furnaces; Underwriters Laboratory (UL) 729–1974 for oil fueled floor furnaces; and UL 730–1974 for oil fueled wall furnaces. These standards measure the steady state efficiency of vented home heating equipment but do not account for any part load or seasonal performance effects. In order to estimate the seasonal efficiency and annual operating cost of fossil fuel vented home heating equipment, it is

necessary to account for the various heating system losses under cyclic or part load operating conditions and for the effect of combustion and draft control air on infiltration. The test procedures and calculation methods formulated by NBS and proposed herein today, account for these factors.

Under the requirements of section 32 of the Federal Energy Administration Act of 1974 (15 U.S.C. 761 et. seq.), as amended by section 9 of the Federal Energy Administration Authorization Act of 1977 (Pub. L. 95–70), the Administrator must name in the notice of rulemaking any non-governmental organization which promulgated commercial standards contained in, authorized by, or required to be used by, a proposed rule. Additionally, the Administrator must ascertain the extent to which the named organization is structured, in membership and in standards-development procedures, to allow for public participation and representation, and render a determination as to whether or not the organization achieves the degree of public participation called for by section 32 (b) of the Act.

Following recommendations made by NBS, the FEA has incorporated commercial standards promulgated by the following organizations in this proposed rulemaking: American National Standards Institute, American Society for Testing and Materials, and Underwriters Laboratory. An additional standard, American Wire Gauge, which was developed by the now defunct Brown and Sharpe Company, has also been incorporated. None of these orgaizations had memberships, at the time of the promulgation of the standards, which were sufficiently balanced as to allow effective representation of all interested persons within the meaning of section 32(b). In this regard, the Administrator has determined that these organizations do not provide for the full range of public participation that section 32(b) sets forth.

In this rulemaking, FEA is providing interested persons an opportunity to comment on the appropriateness of these standards as used in the vented home heating equipment test procedure. Comments are specifically requested on any specific changes the person commenting believes are necessary to make the standards appropriate for the purposes of testing vented home heating equipment.

Today's proposal adds to § 430.2 a definition of "vented home heating equipment" and amends the definition in § 430.2 of "Basic Model" by adding a subparagraph (15) applying specifically to vented home heating equipment. In addition, § 430.2 contains definitions promulgated or proposed previously (42 FR 15423, March 22, 1977) some of which are applicable to the test procedures for vented home heating equipment. Comments on these definitions are timely as provided below.

B. *Measures of Energy Consumption.*

The Act requires FEA to prescribe test procedures for the determination of estimated annual operating costs and at least one other useful measure of energy consumption which the Administrator determines is likely to assist consumers in making purchasing decisions. The estimated annual operating cost for vented home heating equipment in proposed § 430.22(o) is based upon the average annual energy consumption of the vented home heating equipment and the representative average unit cost of energy.

NBS has developed a method of calculating a typical annual cost of operation for vented home heating equipment which takes into account the annual fuel utilization efficiency, the heating load hours, the residence design heat loss, the auxiliary electrical energy used by circulating air fan motors, powered burner motors, and the pilot input rate if applicable.

Also proposed in § 430.22(o) are test procedures regarding the estimated annual operating cost by geographic region of the United States, since energy consumption and annual operating cost of vented home heating equipment are directly related to geographic location. Annual cost of operation by geographic location may be useful for consumers in making purchasing decisions with respect to vented home heating equipment in addition to the single national average value applicable to any specific unit under proposed § 430.22(o). Also proposed in § 430.22(o) are test procedures for calculating annual operating costs for several standardized design heating requirements for each region in order to facilitate the comparison of operating costs of different sizes of vented home heating equipment.

The proposed test procedures for regional costs will incorporate a map of the continental United States with regional "heating load hours" for adjusting the representative average use cycle (typical annual usage) of vented home heating equipment by geographic location. These regional values of "heating load hours" are based on the average number of degree days and the outdoor design temperature for each region.

An additional proposed measure of energy consumption in § 430.22(o) that is likely to assist consumers in making purchasing decisions is the fuel utilization efficiency. This efficiency is the ratio of the heater's annual output of useful energy to the annual fuel energy input of the heater multiplied by 100. The test procedures are designed to measure the fuel utilization efficiency at a part load operating condition in order to account for both on-cycle energy losses and off-cycle energy losses. Both types of losses can be influenced by the design characteristics and features of the heating equipment.

On-cycle losses include:

(1) Energy contained in the combustion gases which are discharged outdoors through the flue;

(2) The loss of heated room air used for combustion at the burner and for dilution of hot combustion gases through the integral draft diverter or barometric draft regulator.

Off-cycle losses include:

(1) The loss of heat stored in the metal of the heat exchanger when the burner and circulating warm air blower shuts off;

(2) The loss of heated room air which escapes through the open heater stack pipe to the outdoors;

(3) Fuel input to a continuously burning gas pilot.

FEA recognizes that there may be additional useful measures of energy consumption for vented home heating equipment other than the measures described above. Accordingly, today's proposal, in proposed § 430.22(o), provides for the addition of other useful measures which the Administrator determines are likely to assist consumers in making purchasing decisions. These measures, however, must be derived from the application of the uniform test methods proposed today as Appendix O to Subpart B. Vented home heating equipment manufacturers would, if required, only have to perform different computations with the data generated by the existing test methods contained in Appendix O.

C. *Laboratory Methodology.*

The proposed test procedures are based upon the heat loss method, in which the sensible and latent heat losses through the stack are determined. Since these losses will depend upon such factors as load, cycling rate, chimney height, oversizing, the type of draft control device, the infiltration characteristics of a residence and the weather profile, it is desirable to measure in the laboratory quantities which characterize the performance of a vented heater under standardized laboratory test conditions and then to calculate its performance under typical field conditions. This has the advantage of simplifying the amount of experimental laboratory data required and thereby reducing the costs of testing.

The test procedures require measurement of the steady-state performance of a vented heater in order to calculate a steady-state efficiency. For vented heaters without integral draft diverters, this is accomplished by measuring the steady-state flue gas temperature and the concentration by volume of carbon dioxide in the flue gas. For vented heaters utilizing integral draft diverters, the steady-state performance is determined by measuring the steady-state stack gas temperature and the concentration by volume of carbon dioxide in the dry stack gas. This latter method is employed because of the difficulty in accurately measuring flue gas temperatures and concentrations of carbon dioxide in units with integral draft diverters.

The test procedures account for cyclic effects by measuring flue gas temperatures during warm-up from a cold start (for gas fueled heaters) and during cool-down from steady-state operation. As noted above, actual flue gas temperature measurements on vented heaters with integral draft diverters are difficult to make. However, for purposes of accounting for transient effects, it was determined that flue gas temperatures could be measured by blocking the integral draft diverter relief opening, replacing

the 5 foot stack with a 2 foot length of pipe, and measuring the temperature and CO_2 concentration of the flue gas. The flue gas temperature profiles are determined by making two discrete flue gas temperature measurements during warm-up and three discrete measurements during cool-down. The use of discrete warm-up and cool-down temperature measurements reduces the amount of data required and greatly simplifies the process of data reduction. The times at which these discrete flue gas temperature measurements are made were chosen to minimize the errors involved in calculating the on-cycle losses.

In addition to the above mentioned tests, certain factors, which describe the flow rates through the flue and stack during the on and off-periods, are assigned according to the type of equipment under test. The factor S/F, which is the ratio of stack gas mass flow rate to flue gas mass flow rate under steady-state operation and at an average outdoor temperature of 42° F (5.56° C), is used to estimate the infiltration losses during both the on and off-cycles. By assigning values which are based upon field data, the need to simulate field conditions in the laboratory (e.g., a high chimney, a low outdoor temperature, a typical barometric draft regulator setting, etc.) is avoided. A factor D_F represents the ratio of the gas mass flow rate through the flue during the off-cycle to the gas mass flow rate through the flue during the on-cycle at identical temperatures. A similar quantity, D_S, is the ratio of the stack gas mass flow rates during the on-period to the stack gas mass flow rate during the off-period at identical temperatures. The values of D_F and D_S depend upon whether the system being tested employs a stack damper and/or a power burner. If a unit is equipped with a stack damper, its effectiveness is determined by measuring the amount of stack area which the damper blocks during the off-cycle. Vented heaters using power burners may employ an assigned power burner factor of D_P=0.30 or measure D_P directly by employing a tracer gas to determine the mass flow rate in the flue while the power burner is off.

Wherever possible the test methods recommended herein have been based upon existing consensus standards and procedures presently employed by manufacturers to evaluate the performance of vented home heating equipment. This was done to reduce the amount of duplicate testing required and to obtain a set of performance tests which would be within the capabilities of the entire home heating industry.

A step-by-step calculation procedure for determining fuel utilization efficiency based upon an average U.S. weather pattern is given in sections 4.1 and 4.2 for gas and oil fueled vented heaters. This efficiency factor is used to estimate the annual cost of operation in different climatic regions and an average operating cost for the country. The technical background, assumptions and equations which form the basis for the fuel utilization efficiency calculation and annual operating cost calculation are contained in Appendix A of the NBS test procedure review document. A worksheet is illustrated which may be used to keep track of the experimental data and the various step-by-step calculations.

Assigned values of the factors S/F, D_F and/or D_S are given in Tables 1 and 2. The factor ϕ is the fraction of combustion and draft control air which contributes to additional residential infiltration. NBS has determined this factor typically equals 0.70 for vented heaters using indoor air. The quantity $(1 + \alpha)$ is the ratio of the heater's steady-state output to the design heating requirement of a typical residence and is set equal to 1.70 for the purpose of calculating a fuel utilization efficiency and an average national operating cost.

The steady-state latent and sensible heat losses and the steady-state efficiency, η_{ss}, are also calculated in section 4.1. The flue-gas and stack-gas temperature profiles, corresponding to warm-up from a cold start and cool-down from steady-state operation, are then approximated by simple exponential functions having the form

$$(ae^{-t/\tau}+b).$$

The parameters in these functions

τ_{ON}, τ_{OFF}, $\theta_{F,0,X}$, $\psi_{F,0,X}$, $\psi_{F,\infty,X}$, $\psi_{S,0,X}$, and

$$\psi_{S,\infty,X}$$

are determined from the warm-up, cool-down and steady-state flue temperature measurements and are corrected for the effect of cycling to obtain the flue-gas and stack-gas temperature-vs-time profiles which would exist if the unit were operating in the field at a heating load factor equal to 22.5 percent. For units designed to use outdoor air for combustion and draft control, a further adjustment to these profiles are made using a correction factor C, to account for the fact that the air used to combustion has an average temperature of 42° F (5.56° C).

The flue-gas and stack-gas temperature-vs-time profiles are employed, along with the factors describing the on- and off-cycle air flow rates, to calculate the dynamic system losses $L_{S,on}$, $L_{S,off}$, $L_{I,on}$, and $L_{I,off}$ at the average heating load factor and the average outdoor temperature of 22.5 percent and 42° F (5.56° C), respectively. These losses, together with the latent heat loss, jacket loss on outdoor units, and the pilot light energy loss during the nonheating season, are then used to calculate an annual fuel utilization efficiency, $EFFY_A$.

D. *Representative Average Use Cycle.*

Section 323(b)(2) (42 U.S.C. 6293(b)(2)) of the Act provides that test procedures for determining estimated annual operating costs of any covered product shall be calculated from measurements of energy use in a representative average-use cycle (as determined by the Administrator) and from representative average unit costs (as provided by the Administrator) needed to operate such product during such cycle. FEA has determined that the representative average-use cycle for vented home heating equipment is 2,080 heating load hours per year. This determination is based upon an NBS recommendation to FEA. The NBS recommendation is included in the NBS test procedure review document which is available for inspection as provided for later in this notice.

The average use cycle of 2,080 heating load hours for vented heaters was derived in an analysis performed by NBS which considered outdoor temperature data extending over a 25 year period at locations in each of the 48 states in the continental United States and the District of Columbia. In addition, the number of housing units in each state using gas or oil as the primary fuel for heating as reported in the 1970 U.S. Census, was also used in the analysis.

Using the number of housing units by state as a weighting factor, and the average outdoor design temperature at each location, a national average outdoor design temperature was calculated to be 5° F. A similar computation was performed using average annual heating degree day values for each state resulting in a national average of 5,200 heating degree days. The average annual heating load hours was then calculated by multiplying the average number of degree days by 24 and dividing that result by the temperature difference between 65° F and the average outdoor design temperature; the result being 2,080 heating load hours per year.

FEA has developed representative average unit costs of energy needed to calculate the annual operating cost for the representative average use cycle. This information was provided by notice issued July 11, 1977 (42 FR 36549, July 15, 1977).

E. *Number of Units to be Tested.*

Proposed § 430.23(o) would provide for sampling of each basic model to be tested when testing of vented home heating equipment is required by the Act or by program regulations of agencies responsible for administering the Act. This provision is intended both to provide an acceptable level of assurance that test results are applicable to any entire basic model for which testing is required and to minimize the testing burden on manufacturers. FEA believes that the sampling approach proposed today will enable consumers to make meaningful comparisons of information appearing on appliance labels, and also will meet the requirements of section 323(b) of the Act that test procedures not be unduly burdensome to conduct.

Under proposed § 430.23 (o), a sample of sufficient size of each basic model would be tested to assure that, for each measure of energy consumption described in § 430.22(o), there is a 95 percent probability that the mean of the values of these measures of the sample is within 5 percent of the true mean of these measures of the basic model. The size of the sample of a particular basic model will depend upon the following factors:

(1) the level of confidence required (set at 95 percent in the proposed regulations);

(2) the maximum allowable difference between the sample mean and the mean of the basic model (expressed in the proposal as a percent of the true mean and set at 5 percent); and

(3) the relationship of the mean and standard deviation of the basic model.

The relationship of the mean and standard deviation of the basic model can be determined from data available to manufacturers. With this information and using standard statistical techniques, manufacturers can determine the number of units required to be tested. In any case, at least 1 unit of each basic model must be tested. Sample units would be selected randomly from the production stream.

Manufacturers and other interested persons are encouraged to comment on the sampling approach. Manufacturers are especially encouraged to submit any data which relates to the size of the samples which the provision would require to be tested. Comments alleging that the sampling provision is burdensome should include a full discussion of the facts upon which such allegation is based.

F. *Request for Particular Comments.*

While FEA is soliciting comments on all aspects of the proposed test procedures for vented heaters, FEA is particularly interested in receiving comments on the following subjects:

1. Other useful measures of energy consumption or data on typical consumer usage of vented home heating equipment in addition to those proposed today.

2. Definitions already promulgated or proposed in § 430.2 which may affect the testing of vented home heating equipment. Comments with respect to such definitions are timely until the close of the written record as specified below.

In addition to the definition of basic model for vented home heating equipments, the following definitions are proposed today: vented home heating equipment; vented wall furnace; vented floor furnace; vented room heater; and direct vent system.

The following definitions previously proposed in § 430.2 (41 FR 19377) are hereby withdrawn: vented gas and oil fired room heater; vented circulator; fan type vented circulator; and vented overhead heater.

G. *Comment Procedure.*

1. *Written Comment.* Interested persons are invited to participate in this rulemaking by submitting data, views or arguments with respect to the proposed test procedures for vented home heating equipment or the proposed target hearing set forth in this notice to Executive Communications, Room 3317, Federal Energy Administration, Box OQ, (proposed test procedure) or Box NU (proposed target), Washington, D.C. 20461.

Comments should be identified on the outside of the envelope and on documents submitted to FEA with the designation "Vented Home Heating Equipment—Proposed Test Procedures" or "Home Heating Equipment—Proposed Target," respectively. Fifteen copies should be submitted. Comments received by October 25, 1977, before 4:30 p.m., and all other relevant informaion, will be considered by FEA before final action is taken on the proposed test procedures.

Any information or data considered confidential by the person furnishing it must be so identified in writing, and only one copy of the information need be submitted. FEA reserves the right to determine the confidential status of the information or data and treat it according to its determination.

2. *Public Hearings.* (a) *Request procedure.* The time and place of these public hearings are indicated at the beginning of this preamble. The hearings will be continued, if necessary, on November 3, 1977.

FEA invites any person who has an interest in the proposed rulemaking issued today, or who is a representative of a group or class of persons that has an interest, to make a written request for an opportunity to make an oral presentation. Such a request should be directed to the address indicated at the beginning of this preamble and must be received before 4:30 p.m., on October 21, 1977. Such a request may be hand delivered to such address, between the hours of 8:00 a.m. and 4:30 p.m., Monday through Friday. A request should be labeled both on the document and on the envelope "Venter Home Heating Equipment—Proposed Test Procedures" or "Home Heating Equipment—Proposed Target", respectively.

The person making the request should briefly describe the interest concerned; if appropriate, state why she or he is a proper representative of a group or class of persons that has such an interest; and give a concise summary of the proposed oral presentation and a telephone number where she or he may be contacted through November 2, 1977.

FEA will notify each person selected to appear at the hearing before 4:30 p.m., October 26, 1977. Each person selected to be heard must submit 50 copies of her or his statement to the address and by the date given in the beginning of this preamble. In the event any person wishing to testify cannot meet the 50 copy requirment, alternative arrangements can be made with the Office of Regulations Management in advance of the hearing by so indicating in the letter requesting an oral presentation or by calling the Office of Regulations Management at 202–254–3345.

(b) *Conduct of Hearings.* FEA reserves the right to select the persons to be heard at these hearings, to schedule their respective presentations and to establish the procedures governing the conduct of the hearings. The length of each presentation may be limited, based on the number of persons requesting to be heard.

An FEA official will be designated to preside at the hearings. These will not be judicial or evidentiary-type hearings. Questions may be asked only by those conducting the hearings, and there will be no cross-examination of persons presenting statements. Any decision made by FEA with respect to the subject matter of the hearings will be based on all information available to FEA. At the conclusion of all initial oral statements at each hearing, each person who has made an oral statement will be given the opportunity if she or he so desires, to make a rebuttal statement. The rebuttal statements will be given in the order in which the initial statements were made and will be subject to time limitations.

Any interested person may submit questions to be asked of any person making a statement at the hearings to Executive Communications, FEA, before 4:30 p.m., October 25, 1977. FEA will determine whether the question is relevant, and whether the time limitations permit it to be presented for answer.

Any person who makes an oral statement and who wishes to ask a question at the hearings may submit the question, in writing, to the presiding officer. The presiding officer, will determine whether the question is relevant, and whether the time limitations permit it to be presented for answer.

Any further procedural rules needed for the proper conduct of the hearings will be announced by the presiding officer.

A transcript of each hearing will be made and the entire record of each hearing, including the transcript, will be retained by FEA and made available for inspection at the FEA Freedom of Information Office, Room 2107, Federal Building, 12th and Pennsylvania Avenue NW., Washington, D.C., between the hours of 8:00 a.m. and 4:30 p.m., Monday through Friday. Any person may purchase a copy of the transcript from the reporter. A copy of NBS's recommendations concerning test procedures for vented home heating equipment, and technical and economic papers relating to the proposed efficiency improvement target will be made available for inspection at the FEA Freedom of Information Office.

H. *Environmental and Inflationary Review.*

As required by section 7(c)(2) of the Federal Energy Administration Act of 1974 (Pub. L. 93–275), a copy of this notice has been submitted to the Administrator of the Environmental Protection Agency for his comments concerning the impact of this proposal on the quality of the environment. The Administrator has no comments.

The National Environmental Policy Act of 1969 requires FEA to assess the environmental impacts of any proposal by the Agency for "major Federal actions significantly affecting the quality of the human environment." Since test procedures under the conservation program for appliances will be used only to standardize the measurement of energy usage and will not affect the quantity or distribution of energy usage, FEA has determined that the action of prescribing test procedures, by itself, will not result in any environmental impacts. On this basis, FEA has determined that, with

respect to prescribing test procedures under the conservation program for appliances, no environmental impact statement is required.

The proposal has been reviewed in accordance with Executive Order 11821 as amended by Executive Order 11949, and OMB Circular No. A–107 and has been determined not to be a major proposal requiring evaluation of its economic impact as provided for therein.

(Energy Policy and Conservation Act, Pub. L. 94–163, as amended by Pub. L. 94–385; Federal Energy Administration Act of 1974, Pub. L. 93–275, as amended by Pub. L. 94–385; E.O. 11790, 39 FR 23185.)

In consideration of the foregoing, it is proposed to amend Chapter II of Title 10, Code of Federal Regulations, as set forth below.

Issued in Washington, D.C., August 22, 1977.

ERIC J. FYGI,
Acting General Counsel,
Federal Energy Administration.

1. Section 430.2 is amended by adding a subparagraph (15) as part of the definition of "basic model" and by adding the definitions of "vented home heating equipment," "vented wall furnace," "vented floor furnace," "vented room heater" and, "direct vent system," to read as follows:

§ 430.2 Definitions.

* * * * *

"Basic model" means all units of a given type of covered product manufactured by one manufacturer and:

* * * * *

(15) With respect to furnaces, having the same primary energy source and essentially identical functional physical and electric characteristics.

* * * * *

"Vented home heating equipment" or "vented heater" means a class of home heating equipment, not including furnaces, designed to furnish warmed air to the living space of a residence, directly from the device without duct connections (except that boots not to exceed 10 inches beyond the casing may be permitted) and includes: vented wall furnace, vented floor furnace, and vented room heater.

"Vented wall furnace" means a self-contained vented heater complete with grilles or the equivalent, designed for incorporation in or permanent attachment to the structure of a residence and furnishing heated air circulated by gravity or by a fan directly into the space to be heated through openings in a casing.

"Vented floor furnace" means a self-contained vented heater suspended from the floor of the space being heated, taking air for combustion from outside this space. The vented floor furnace supplies heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing.

"Vented room heater" means a self-contained, free standing, nonrecessed, vented heater for furnishing warmed air to the space in which it is installed. The vented room heater supplies heated air circulated by gravity or by a fan directly into the space to be heated through openings in the casing without duct connections.

"Direct vent system" means a system consisting of a vented heater and combustion air and flue gas connections between the vented heater and the outside atmosphere, and constructed so that all air for combustion is obtained from the outside atmosphere and all flue gases are discharged to the outside atmosphere.

2. Section 430.22 is amended by adding paragraph (o), to read as follows:

§ 430.22 Test Procedures for Measures of Energy Consumption.

* * * * *

(o) *Vented home heating equipment.* (1) The estimated annual operating cost for vented home heating equipment shall be the sum of: (i) the product of the average annual fuel energy consumption in Btu's per year, determined according to 4.7 of Appendix O of this subpart, and the representative average unit cost in dollars per Btu for gas or oil, as appropriate as provided by the Administrator plus (ii) the product of the average annual auxiliary electric energy consumption in kilowatt-hours per year, determined according to 4.8 of Appendix O of this subpart, and the representative average unit cost in dollars per kilowatt-hour as provided by the Administrator, the resulting sum then being rounded off to the nearest dollar per year.

(2) The annual fuel utilization efficiency for vented home heating equipment, expressed in percent, shall be the ratio of annual output of useful energy delivered to the heated space to the annual fuel energy input to the vented heater determined according to 4.1.33 of Appendix O of this subpart.

(3) The estimated regional annual operating costs for vented home heating equipment computed for minimum and maximum standardized design heating requirements shall be the sum of: (i) the product of the regional annual fuel energy consumption for the minimum or maximum standardized design heating requirement, as appropriate, in Btu's per year for gas or oil vented heaters determined according to 4.16 or 4.17 of Appendix O of this subpart, and the representative average unit cost in dollars per Btu for gas or oil, as appropriate, as provided by the Administrator plus (B) the product of the regional annual auxiliary electrical energy consumption in kilowatt-hours per year determined according to 4.18 or 4.19, as appropriate, of Appendix O of this subpart, and the representative average unit cost in dollars per kilowatt-hour as provided by the Administrator, the resulting sum then being rounded off to the nearest dollar per year.

(4) The estimated regional annual operating cost for vented home heating equipment shall be the sum of: (i) the product of the regional annual fuel energy consumption in Btu's per year determined according to 4.10 of Appendix O of this subpart, and the representative average unit cost in dollars per Btu for gas or oil, as appropriate, as provided by the Administrator plus (ii) the product of the regional auxiliary electrical energy consumption in kilowatt-hours per year, determined according to 4.11 of Appendix O of this subpart, and the representative average unit cost in dollars per kilowatt-hour as provided by the Administrator, the resulting sum then being rounded off to the nearest dollar per year.

(5) Other useful measures of energy consumption for vented home heating equipment shall be those measures of energy consumption which the Administrator determines are likely to assist consumers in making purchasing decisions and which are derived from the application of Appendix O of this subpart.

3. Section 430.23 is amended by adding a paragraph (o) to read as follows:

§ 430.23 Units to be tested.

* * * * *

(o) *Vented home heating equipment.* (1) When testing of vented home heating equipment is required for a measure or measures of energy consumption described in § 430.22(o) of this subpart, a sample of sufficient size of each basic model shall be tested to ensure that, for each such measure of energy consumption, there is a 95 percent probability that the mean of the sample is within 5 percent of the true mean of such measures of the basic model, except that a minimum of 1 unit of each basic model shall be tested.

(2) The sample selected for paragraph (o)(1) of this section shall be a simple random sample drawn from the production stream of the basic model being tested.

(3) A basic model having dual voltage ratings shall be separately tested at each design voltage such that the requirements of paragraph (o)(1) of this section is satisfied at each rating.

* * * * *

APPENDIX O—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF VENTED HOME HEATING EQUIPMENT

1.0 DEFINITIONS.

1.1 "Steady-state conditions for vented home heating equipment" means equilibrium conditions in the flue or stack gas as indicated by temperature changes of not more than plus or minus 5° F (2.8° C) in three successive temperature readings taken 15 minutes apart.

1.2 "Flue gases" means reaction products resulting from the combustion of a fuel with the oxygen of the air, including the inerts and any excess air.

1.3 "Excess air" means air which passes through the combustion chamber and the vented heater flues in excess of that which is theoretically required for complete combustion.

1.4 "Flue" means a conduit between the flue outlet of a vented heater through which the flue gases pass prior to the point of draft relief.

1.5 "Flue outlet" means the opening provided in a vented heater for the exhaust of the flue gases from the combustion chamber.

1.6 "Flue losses" means the sum of sensible and latent heat losses above room temperature (70° F) of the flue gasses leaving a vented heater.

1.7 "Stack" means the portion of the exhaust system downstream of the barometric draft regulator or integral draft diverter.

1.8 "Stack gases" means the flue gases combined with dilution air that enters at the barometric draft regulator or integral draft diverter.

1.9 "Barometric draft regulator" means a mechanical device designed to maintain a constant draft in a vented heater.

1.10 "Air shutter" means an adjustable device for varying the size of the primary air inlet(s) to the combustion chamber.

1.11 "Power burner" means a burner which supplies either gas or air or both at pressures exceeding, for gas, the line pressure, and for air, atmospheric pressure, or a burner which depends on the draft induced by a fan for proper operation.

1.12 "Vent limiter" means a device which limits the flow of air from the atmospheric diaphragm chamber of a gas pressure regulator to the atmosphere. A vent limiter may be a limiting orifice or other limiting device.

1.13 "Exhaust air intake terminal" means a device which is located on the outside of a building and is connected to a vented heater by a system of vents. It is composed of an air intake terminal through which the air for combustion is taken from the outside atmosphere, and a vent terminal from which flue gases are discharged.

1.14 "Induced draft" means a method of drawing air into the combustion chamber by mechanical means.

1.15 "Plenum" means an air compartment, that is attached to, or is an integral part of, a vented heater and which is designed to either distribute the heated air after it leaves the heat exchanger in the case of a supply plenum, or collects the air which enters the return inlet in the case of a return plenum.

1.16 "Heat input" (Q_{in}) means the rate of energy supplied in a fuel to a vented heater, operating under steady state conditions, expressed in Btu's per hour. It includes any input energy to the pilot light and is obtained by multiplying the measured rate of fuel consumption by the measured higher heating value of the fuel.

1.17 "Higher heating value" (HHV) means the heat produced per unit of fuel when complete combustion takes place at constant pressure and the products of combustion are cooled to the initial temperature of the fuel and air and the water vapor formed during combustion is condensed. The higher heating value is usually expressed in Btu's per cubic foot for gaseous fuel, or Btu's per gallon for liquid fuel.

1.18 "Integral draft diverter" means a device which is an integral part of a vented heater, which is designed to (1) provide for the exhaust of the products of combustion in the event of no draft, back draft, or stoppage beyond the draft diverter, (2) prevent a back draft from entering the vented heater, (3) neutralize the effect of stack action of the chimney or gas vent upon the operation of a vent heater.

1.19 "Vent damper" means a device intended for installation in the exhaust system of a vented heater, and which is designed to open the exhaust system when the vented heater is in operation and to close off the exhaust system when the vented heater is in a stand-by condition.

1.20 "Vent pipe" means passages and conduits in a direct vent system through which gases pass from the combustion chamber to the outdoor air.

1.21 "Infiltration parameter" means that portion of unconditioned outside air drawn into the heated space as a consequence of loss of conditioned air through the exhaust system of a vented heater.

1.22 "Vaporizing type oil burner" means a device consisting of an oil vaporizing bowl or other receptacle into which liquid fuel oil may be fed in controllable quantities; the heat of combustion being used to vaporize the fuel, with provision for admitting air and mixing it with the oil vapor in combustible proportions.

1.23 "Air tube" means a tube which carries combustion air from the fan to the burner nozzle, for combustion.

2.0 TESTING CONDITIONS.

2.1 *Installation of Test Unit.*

2.1.1 Vented Wall Furnaces (including direct vent systems). Gas fueled vented wall furnaces shall be installed for test as specified in Sections 2.1.3 and 2.1.4 of ANSI Z21.49–1975. Gas fueled wall furnaces with direct vent systems shall be installed for test as described in 2.1.2 and 2.1.4 of ANSI Z21.44–1973. Oil fueled vented wall furnaces shall be installed as specified in UL–730–1974, Section 33. Oil fueled vented wall furnaces with direct vent systems shall be installed as specified in UL–730–1974, section 34.

2.1.2 Vented Floor Furnaces. Vented floor furnaces shall be installed for test as specified in Sections 35.1 through 35.5 of UL standard 729–1974.

2.1.3 Vented Room Heaters. Installation shall be made in accordance with manufacturer's instructions.

2.2 *Flue and Stack Requirements.*

2.2.1 Gas fueled vented home heating equipment employing integral draft diverters.

For the steady state performance test described below, gas fueled vented home heating equipment employing integral draft diverters with vertically discharging outlets shall have attached to and vertically above the outlet, a stack having a diameter the same size as the outlet and shall be covered with insulation having an R value of not less than 7 (°F–HR–Ft²/Btu) and an outer layer of aluminum foil. The stack shall extend not less than 5 feet nor more than five feet six inches above the highest point of the outlet. Vented heaters having a horizontally discharging outlet shall have attached an insulated 90 degree elbow, the same size as the outlet, and sufficient vertical insulated black iron pipe so that the pipe outlet is not less than five feet nor more than five feet six inches above the highest point of the heater outlet. A horizontal section of pipe may be used on the floor furnace between the diverter and the elbow if necessary to clear any framing used in the installation. The length of this section of pipe shall be the minimum needed. The stack and elbow shall be covered with insulation having an R value of not less than 7 (°F–HR–Ft²/Btu) and an outer layer of aluminum foil.

The tests for measuring flue gas temperatures during warmup and cooldown, and for the steady state test of section 3.1.1.3, shall be conducted by replacing the five to five feet six inch pipe of the previous paragraph with a two foot vertical pipe. The pipe shall be covered with insulation having an R value of not less than 7 (°F–HR–Ft²/Btu) and an outer layer of aluminum foil.

2.2.2 Gas fueled vented home heating equipment which does not employ integral draft diverters. Gas fueled vented home heating equipment which does not employ integral draft diverters shall have a two foot long insulated pipe attached to the vertically discharging flue outlet for the steady state test and the tests to measure flue temperatures during warm-up and cooldown. For units having a horizontally discharging outlet, an elbow and a two foot long vertical insulated pipe shall be attached to the outlet. All insulation shall have an R value not less than 7 (°F–HR–FT²/Btu) and an outer layer of aluminum foil.

2.2.3 Oil Fueled Vented Home Heating Equipment. Flue connections for oil fueled vented floor furnaces shall be specified in Section 35 of UL–729–1974, Section 34.10 through 34.18 of UL–730–1974 for oil fueled vented wall furnaces and Sections 36.2 and 36.3 of UL–896–1973 for vented room heaters.

There shall be no opening on the oil heater between the heater and the point where the flue gas sample is to be taken or the flue gas temperature is to be measured. If a barometric draft regulator is incorporated in the heater, it shall be sealed during all tests.

2.2.4 Direct Vent Systems. The exhaust/air intake system supplied by the manufacturer shall be in place during all tests. A vented heater employing a direct vent system shall not be connected to a chimney or induced draft source, but shall depend for venting of the gas solely on the provision for venting incorporated in the heater and the exhaust/air intake system supplied with it. On units which are not designed to preheat the incoming air, the first 18 inches of vent pipe downstream of the heater outlet shall be insulated with a layer of insulation having an R value of 7 (°F–HR–FT²/Btu) and the insulation material covered by a layer of aluminum foil.

2.3 *Fuel Supply.*

2.3.1 Natural Gas. For a vented heater utilizing natural gas, maintain the gas supply to the unit under test at a normal inlet test pressure immediately ahead of all controls at 7 to 10 inches water column. The regulator outlet pressure at normal test pressure shall be approximately that recommended by the manufacturer. Use natural gas having a specific gravity of approximately 0.6 and a higher heating value within ±5% of 1025 Btu per standard cubic foot. Determine the actual higher heating value in Btu's per standard cubic foot for the natural gas to be used in the test with an error no greater than one percent.

2.3.2 Propane Gas. For a vented heater utilizing propane gas, maintain the gas supply to the unit under test at a normal inlet pressure of 11 to 13 inches water column and a specific gravity of 1.55. The regulator outlet pressure at normal test pressure shall be approximately that recommended by the manufacturer. Use propane having a specific gravity of approximately 1.55 and a higher heating value within ±5% of 2500 Btu's per standard cubic foot. Determine the actual higher heating value in Btu's per standard cubic foot for the propane to be used in the test with an error no greater than one percent.

2.3.3 Other Test Gas. The characteristics of other test gases shall be maintained as described in Section 2.2, Table VII, of ANSI Standard Z21.11.1–1974. Their measured higher heating value shall be within ±5% of the values specified in the above ANSI standard.

2.3.4 Oil Supply. For a vented heater utilizing fuel oil, the fuel oil type used shall be No. 1 fuel oil for vaporizing type burners and as specified by the manufacturer for mechanical atomizing type burners. The No. 1 fuel oil viscosity shall be as specified in UL–730–1974, Section 36.9. The specification of other fuel oils shall be as defined in ANSI Z11.203–1970.

The higher heating value of the test fuel oil shall be measured with an error no greater than one percent.

2.3.5 Electrical Supply. For an auxiliary electric component of a vented heater, maintain the electrical supply to the test unit within one percent of the nameplate voltage for the entire portion of the test cycle. If a voltage range is used for nameplate voltage, maintain the electrical supply within one percent of the center of the nameplate voltage range.

2.4 *Burner Adjustments.*

2.4.1 Gas Burner Adjustments. Burners of gas fueled vented heaters shall be adjusted to their maximum Btu ratings at normal test pressure. All such adjustments shall be within ±2 percent of the hourly Btu rating specified by the manufacturer as measured after 15 minutes of operation starting with all parts of the furnace at room temperature. The primary air shutters shall be set for proper combustion, or as determined by manufacturer's recommendation, and the burner input flow rate shall be corrected to standard conditions of 60° F and 30 inches mercury barometric pressure.

If a vent limiting means is provided on a gas pressure regulator, it shall be in place during all tests.

2.4.2 Oil Burner Adjustments. The burners of oil fueled vented heaters shall be adjusted to give the best CO_2 reading and a hourly Btu input, during the steady-state performance test described below, which is within plus or minus 2 percent of the heater manufacturer's specified normal hourly Btu input rating. Smoke in the flue shall not exceed a No. 2 smoke during the steady-state performance test as measured by the procedure in ANSI Standard Z11.182–1965 (R1971) (ASTM D 2156–65 (1970)). The averge draft over the fire and in the flue during the steady-state performance test shall be that recommended by the manufacturer and draft fluctuations shall not exceed 0.005 inches of water gauge. No additional adjustments to the burner shall be made during the required series of performance tests. The instruments and measuring apparatus for this test are described in Section 6.3 of ANSI Standard Z91.1–1972.

2.5 *Circulating Air Adjustments.*

2.5.1 Forced Air Vented Wall Furnaces (including direct vent systems). During tests the air flow through the heater shall be as specified by the manufacturer and the heater shall be operated with the outlet air temperature between 80°F and 130°F above room temperature. If adjustable air discharge registers are provided, they shall be adjusted so as to provide the maximum possible air restriction. Air discharge temperature shall be measured as specified in Section 2.14 of ANSI Z21.49–1975.

2.5.2 Fan Type Vented Room Heaters and Floor Furnaces. During tests on fan type furnaces and heaters, the air flow through the heater shall be as specified by the manufacturer.

2.6 *Thermocouple Installation.*

2.6.1 Gas Fueled Vented Home Heating Equipment (not including direct vent systems). For units employing an integral draft diverter, install nine thermocouples in a horizontal plane in the five foot length stack at 4 feet 6 inches above the highest point of the heater outlet.

Install one thermocouple in the center of the stack. Install eight thermocouples along imaginary lines intersecting at right angles in this horizontal plane at points one third and two thirds of the distance between the center of the stack and the stack wall.

For those tests requiring a 2 foot length of pipe install one thermocouple in the center of the 2 foot length of insulated flue pipe at the midpoint (i.e., one foot of from the end).

For units which do not employ an integral draft diverter, install nine thermocouples in a horizontal plane 12 inches from the outlet of the 2 foot length of insulated pipe. Install one thermocouple in the center of the pipe and eight thermocouples along imaginary lines intersecting at right angles in this horizontal plane at points one third and two thirds of the distance between the center of the pipe and the pipe wall.

Use bead-type thermocouples having wire size not greater than No. 24 American Wire Gauge (AWG).

Thermocouples whall be installed for measuring conditioned warm air in the numbers and locations decribed in ANSI Z21.49–1975, section 2.14. The temperature of the inlet air shall be established by means of a single No. 24 AWG bead-type thermocouple, suitably shielded from direct radiation and located in the center for the plane of each inlet air opening.

2.6.2 Oil Fueled Vented Home Heating Equipment (not including direct vent systems). Thermocouples shall be installed as described in Section 37.16 of UL 896 "Oil Burning Stoves" for vented room heaters or Section 36.11 of UL 729 for oil fueled vented floor furnaces, or 35.11 or UL 73 for oil fueled vented wall furnaces.

2.6.3 Vented Wall Furnaces with Direct Vent Systems. For vented heaters that are designed to preheat combustion air, install nine thermocouples along two imaginary lines intersecting at right angles inside the vent pipe in a plane parallel to and one inch (25.4mm) from the outlet of the vent pipe. The lines shall be oriented so that they will divide the internal area into quadrants. One thermocouple shall be located at the intersection of the two lines. Eight thermocouples shall be located in sets of two along each line at points one third and two thirds of the distances from the intersection to the periphery. Use beadtype thermocouples not larger than 24 AWG, at the specified locations.

For units not designed to preheat combustion air, locate the nine thermocouples in a plane one foot from the outlet of the heater and in the configuration described above.

2.7 *Combustion Measurement Instrumentation.* The samples of stack and flue gases for vented heaters shall be analyzed to determine the concentration by volume of carbon dioxide present in the dry gas with instrumentation which will result in a reading having an accuracy of ±3 percent.

2.8 *Energy Flow Instrumentation.* Install one or more energy flow instruments to measure the quantity of gas flow or fuel oil supplied to the vented heater, and electrical energy, if appropriate, with an error no greater than one percent.

2.9 *Room Ambient Temperature.* Maintain the test room at an ambient air temperature between 65°F and 75°F. Use the procedure outlined in section 2.1.14 of ANSI Standard Z21.47–1973 to measure room temperature.

2.10 *Equipment Used to Measure Mass Flow Rate in Flue and Stack.* The tracer gas chosen for this task should have a density which is approximately equal to the density of air. It shall be of different chemical species or different concentration from the flue or stack gas to be measured and shall be unreactive with the environment to be encountered. Instrumentation used to measure the concentration of tracer gas may be either the batch or continuous type with an accuracy of ±2% of the value of the concentration measured.

3.0 TESTING AND MEASUREMENTS.

3.1 *Steady-State Testing*

3.1.1 Gas Fueled Vented Home Heating Equipment (not included direct vent systems).

3.1.1.1 Stack Gas Temperature and CO_2 Measurements. The vented heater shall be set up as specified in sections 2.1, 2.2, and 2.3. Begin the steady-state performance test by operating the burner and the circulating air blower with the adjustments specified in 2.4 and 2.5 until a steady-state temperature is attained in the stack gas as measured by the center thermocouple located in the 5 foot stack as specified in 2.6.1 for units employing integral draft diverters.

On units employing integral draft diverters, record the steady-state stack gas temperature ($T_{s,ss,s}$). Measure a sample of dry stack gasses for CO_2, ($Xco_{2,s}$) in the plane of measurement used for measuring flue gas temperature in accordance with ANSI Z21-48-1976, section 2.1.2., Z21-49-1975 section 2.1.2., Z21-11-1976 section 2.8, and Z21-44-1973 section 2.1.1. Measure heat input rate (Q_{in}) including the pilot input and the electrical power input at steady-state conditions and record.

The steady-state heat input rate (Q_{in}) including pilot gas shall be determined by multiplying the measured higher heating value of the test gas by the steady-state gas input rate corrected to standard conditions of 60° F and 30 inches of mercury. Measure gas input temperature and pressure at the meter and the barometric pressure. Correct the metered gas flow rate to standard conditions of 60° F and 30 inches mercury.

Measure the steady-state electric power to the circulating air blower (*BE*) and to the power burner (*PE*) on units so equipped and record the data.

3.1.1.2 Flue Gas Temperature and CO_2 Measurements. After the above test measurements have been completed on units employing integral draft diverters, the 5 to 5½ foot long black iron pipe used in the steady state test shall be removed, the draft diverter relief opening shall be blocked and a 2 foot length of pipe installed as described in section 2.2.1. A single bead-type thermocouple not larger than No. 24 AWG shall be located in the center of the flue pipe and 12 inches from its top. After equilibrium conditions are again achieved, as indicated by changes in the flue gas temperature of not more than 5° F (2.8° C) between readings 15 minutes apart, the steady-state flue gas temperature ($T_{F,ss}$) shall be measured using this single thermocouple and a sample of the flue gases shall be taken in the same plane of measurement. The sample of the flue gases shall be analyzed to determine the concentration by volume of CO_2 ($Xco_{2,F}$) present in the dry flue gas.

On units not employing an integral draft diverter, the steady-state flue gas temperature shall be measured in the 2 foot long flue pipe as described in Section 2.6 and a sample of the flue gas shall be taken in the plane of measurement. The sample of flue gases shall be analyzed to determine the concentration of CO_2, ($Xco_{2,F}$), present in the dry flue gas.

3.1.2 Vented Wall Furnaces with Direct Vent Systems. The vented heater shall be set up and adjusted as specified in sections 2.1, 2.2.4, 2.3, 2.4, 2.5 and 2.6. Flue temperature ($T_{F,ss}$) and CO_2 ($Xco_{2,F}$) measurements shall be performed at steady-state conditions as prescribed in 3.1.1, with the following exception:

Temperature measurements shall be made at a location which is determined by the design provisions of the vented heater for preheating the incoming air as prescribed in section 2.6.3 for thermocouple location.

3.1.3 Oil Fueled Vented Home Heating Equipment (not including direct vent systems). The vented heater shall be set up and adjusted as specified in sections 2.1, 2.2.3 and 2.3.4. Begin the steady-state performance test by operating the burner and the circulating air blower with the adjustments specified by 2.4.2 and 2.5.1. When steady-state temperature ($T_{F,ss}$) is attained in the flue gas, measure the average flue gas temperature and measure CO_2 ($Xco_{2,F}$) in a sample of the flue gas at the location described in figure 37.4 of UL Std. 896. There shall be no opening between the heater and the point where the flue gas sample is to be measured. If a barometric draft regulator is incorporated in the heater, it shall be sealed during all tests.

Measure and record the steady-state heat input rate (Q_{in}). Measure steady-state electrical power to the air blower (*BE*) and to the power burner (*PE*) and record these data.

3.2 *Flue Temperature Measurements—Cool Down Test.*

3.2.1 Vented Home Heating Equipment (not including direct vent dystems). After steady-state testing is completed, all units shall have the main burner turned off and the flue gas temperature measured at 1.5 ($T_{F,OFF(t_1)}$) and 9.0 ($T_{F,OFF(t_4)}$) minutes after the burner shuts off. Units employing stack dampers shall have the damper control by-passed so that the damper remains open during the cool down test. During this off-period the indoor air circulating blower shall be made to operate during the first three minutes of the off period and shall then be turned off unless the vented heater employs a single motor to drive a power burner and an indoor air circulating blower in which case both shall be turned off together. The main burner(s) shall remain off until equilibrium conditions are attained, as indicated by temperature changes in the flue gas of not more than 3°F (2.8°C) between readings 15 minutes apart. For units employing a continuously burning pilot light, a third flue gas temperature measurement shall then be made to determine the off-period minimum flue gas temperature ($T_{F,OFF(\infty)}$). For units not employing a continuously burning pilot light, $T_{F,OFF(\infty)}$ is assumed to equal 70°F (21.1°C). During this cool down test, the energy input rate to the pilot light (Q_p), if the unit is so equipped, shall also be measured to within an accuracy of ±3%. Record all measured values.

3.2.2 Vented Home Heating Equipment with Direct Vent Systems. After steady-state testing has been completed, turn the main burner off and measure the flue gas temperature at 1.5 ($T_{F,OFF(t_1)}$) and 9.0 ($T_{F,OFF(t_4)}$) minutes after the burner is shut off using nine bead-type thermocouples, not larger than 24 AWG, in the locations prescribed in section 2.6.3. During this off-period, the indoor air circulating blower shall be made to operate during the first 3 minutes of the off-period and shall then be shut off unless the vented heater employs a single motor to drive a power burner and an indoor air circulating blower, in which case both shall be turned off. The main burner(s) shall remain off until equilibrium conditions are attained, as indicated by changes in the flue gas temperature of not more than 3°F (2.8°C) between readings 15 minutes apart. For units employing a continuously burning pilot light, a third flue gas temperature measurement shall then be made to determine the off-period minimum flue gas temperature ($T_{F,OFF(\infty)}$). For units not employing a continuously burning pilot light ($T_{F,OFF,(\infty)}$) is assumed to equal 70° F (21.1° C). During this cool down test, the energy input rate to the pilot light (Q_p), if the unit is so equipped, shall also be measured to within an accuracy of ±3%. Record all measured values. If a vented heater with a direct vent system employs an automatic stack damper, it shall be closed during this cool down test.

3.3 *Flue Gas Temperature Measurements Heat Up Test for Vented Home Heating Equipment.* After equilibrium conditions are achieved following the cooldown test and the required measurements performed, the vented heater shall be turned on and the flue gas temperature measured at the locations specified in section 3.2 of this Appendix, at 0.5 ($T_{F,ON(t_1)}$) and 2.5 ($T_{F,ON(t_2)}$) minutes after the main burner(s) comes on. The indoor air circulating fan shall remain off during the first 1.5 minutes of this warm up test and shall then be turned on unless the vented heater employs a single motor to drive a power burner and an indoor air circulating blower, in which case both shall be started together. Record the measured temperatures. Vaporizing type oil burners need not have this test performed.

3.4 *Jacket Loss Measurement.* A jacket loss test is specified only for vented floor furnaces. Measure the jacket loss (L_J) in accordance with the ANSI standard Z21.48-1976 Section 2.12. and record the total jacket loss and the ambient room temperature during the test.

3.5 *Measurement for Determining Effectiveness of Automatic Stack Damper.* The effectiveness of an automatic stack damper (D_e), in vented heaters so equipped, shall be determined by measuring the cross sectional area of the stack (A_S), the net area of the damper plate (A_D) (the area of the damper plate minus the area of any holes in the plate), and the angle Ω which is the angle the damper plate makes when closed with a plane perpendicular to the axis of the stack. The equation in section 4.2 is then employed to calculate D_e.

3.6 *Measurement for Determining D_F for Systems Equipped with Power Burners.* On power burner systems not employing automatic stack dampers or power burner systems with a stack damper and an integral draft diverter, the flue gas temperature during the off-period ($T_{F,OFF}$) may be measured during the cool-down test described in section 3.2. The procedures to be used for measuring ($T_{F,OFF}$) are described below.

On systems equipped with both power burners and stack dampers, and not employing an integral draft diverter, D_F (the ratio of the rate of flue gas mass flow through the vented heater during the off-period to the rate of flue gas mass flow through the vented heater during the on-period) shall be measured during a separate cool-down test. This separate cool-down test shall be conducted after the warm-up test described in Section 3.3 for determining the on-period flue gas temperature. It shall be conducted by letting the unit run after the warm-up test is completed until steady-state conditions are reached, as indicated by temperature changes in the flue gas or not more than plus or minus 5° F (2.8° C) between readings 15 minutes apart, and then shutting the unit off with the stack damper controls by-passed or adjusted so that the stack damper remains open during the resulting cool-down period. If a draft was maintained in the flue during the steady state performance test described in Section 3.1 the same draft (within ±0.01 inches of water gauge of the average value measure during the steady-state tests) shall be maintained during this cool-down period.

The flue gas mass flow rate during the off-period ($m_{F,OFF}$) may be measured at a specific off-period flue gas temperature and then corrected to obtain its value at a flue gas temperature at steady-state ($T_{F,SS}$), using the procedure described below.

Within one minute after the unit is shut off to start the cool down test for determining D_F, begin feeding a tracer gas into the combustion chamber at a constant flow rate of $\dot{V}_T$, and at a point which will allow for the best possible mixing with the air flowing through the chamber. On units equipped with an oil fueled power burner, the best location for injecting this tracer gas is through a hole drilled in the air tube. The value of $\dot{V}_T$ shall be periodically measured with an instantaneously reading flow meter having an accuracy of ±3 percent of the quantity measured and shall be less than 1 percent of the air flow rate through the vented heater. If a combustible tracer gas is used, there should be a delay period between the time the unit is shut off and the time the tracer gas is first injected to prevent ignition of the tracer gas.

Between 5 and 6 minutes after the unit is shut off to start the cool-down test, the percent volumetric concentration of tracer gas, C_T, in the flue gas and the flue gas temperature, $T_{F,OFF}$, shall be measured in the center of the flue pipe on the vented heater side of the draft regulator and not more than 12 inches from the heater flue-gas outlet. In addition, the barometric pressure, P_B, shall also be determined. A single bead-type thermocouple, not larger than No. 24 AWG, shall be used to make the temperature measurement. The concentration of tracer gas shall be obtained using an instrument which will result in an accuracy of ±2 percent in the value of C_T measured and may be either a batch or continuous reading type instrument. If the sampling arrangement for the instrument results in a delay time between the drawing of a sample and its analysis, this delay should be taken into account so that the temperature measurement and the measurement of tracer gas concentration coincide.

The rate of the flue gas mass flow through the vented heater and the factors D_P, D_F, and D_S are calculated by the equations in sections 4.3.1, 4.3.2 and 4.3.3 of this Appendix.

4.0 CALCULATION OF DERIVED RESULTS FROM TEST MEASUREMENTS.

4.1 *Annual Fuel Utilization Efficiency for Gas or Oil Vented Home Heating Equipment.* The following caluclations are to be performed to determine the annual fuel utilization efficiency of gas or oil vented home heating equipment. Figure 10 provides an illustration of a worksheet which may be used to tabulate the results of test measurements and calculations.

4.1.1 System number. Determine the system number for the type of vented heater being tested in accordance with Table 1 or 2.

4.1.2 Ratio of combustion air mass flow rate to stoichiometric air mass flow rate. Determine the ratio of combustion air mass flow rate to stoichiometric air, mass flow rate, $R_{T,F}$, from Figure 1 for the test fuel, by using the value of dry flue gas CO_2 concentration, $Xco_{2,F}$, determined in accordance with section 3.1 of this Appendix.

4.1.3 Ratio of combustion and relief air mass flow rate to stoichiometric air mass flow rate. For systems 1, 2, 5, or 6, employing an integral draft diverter, determine the ratio of the sum of combustion and relief air mass flow rate to stoichiometric air mass flow rate $R_{T,S}$, from Figure 1 for the type of test fuel, by using the value of dry stack gas CO_2 concentration, $Xco_{2,S}$, determined in accordance with section 3.1 of this Appendix.

4.1.4 Average sensible heat loss at full-load steady state operation. For systems 1, 2, 5, or 6, employing an integral draft diverter, determine the average sensible heat loss at full-load steady-state operation, $L_{S,SS,A}$, expressed as a percent, from Figure 2 using the value of $R_{T,S}$ determined in 4.1.3, the type of test fuel, and $\Delta T_{S,SS}$, where

$$\Delta T_{S,SS} = T_{S,SS,X} - 70,$$

where

$T_{S,SS,X}$ = measured stack gas temperature at full-load steady-state operation determined in accordance with section 3.1 of this Appendix, in degrees Fahrenheit

70 = assumed indoor average conditioned air temperature, in degrees Fahrenheit

For systems 3, 4, or, 7 through 12, determine the average sensible heat loss at full-load steady-state operation, $L_{S,SS,A}$, expressed as a percent; from Figure 2 using the value of $R_{T,F}$ determined in 4.1.2, the type of test fuel, and $\Delta T_{F,SS}$, where

$$\Delta T_{F,SS} = T_{F,SS} - 70$$

where

$T_{F,SS}$ = flue gas temperature at full-load steady-state operation determined in accordance with section 3.1 of this Appendix, in degrees Fahrenheit.

70 = as defined above

4.1.5 Steady-state efficiency. Calculate the steady-state efficiency (excluding jacket loss), η_{SS}, expressed in percent and defined as

$$\eta_{SS} = 100 - L_{L,A} - L_{S,SS,A}$$

where

$L_{L,A}$ = average latent heat loss of the test fuel determined in accordance with Table 3, in percent.

$L_{S,SS,A}$ = as defined in 4.1.4.

4.1.6 Average ratio of stack gas mass flow rate to flue gas mass flow rate at full-load steady-state operation. Determine the average ratio of stack gas mass flow rate to flue gas mass flow rate at full-load steady-state operation, $S/_F$, from Table 1 or 2 for the system number to be tested.

4.1.7 Equivalent field stack gas temperature at full-load steady-state operation. Calculate the equivalent field stack gas temperature at full-load steady-state operation, $T_{S,SS}$, expressed in degrees Fahrenheit and defined as:

$$T_{S,SS} = \frac{1}{S/_F}[T_{F,SS} - 70] + 70,$$

where

$T_{F,SS}$ as defined in 4.1.4

70 as defined in 4.1.4

$S/_F$ as defined in 4.1.6

4.1.8 On-cycle time constant. Calculate the on-cycle time constant, τ_{on}, expressed in minutes and defined as:

$$\tau_{on}=\frac{t_2-t_1}{\ln\left[\frac{T_{F,SS}-T_{F,on}(t_1)}{T_{F,SS}-T_{F,on}(t_2)}\right]}$$

where

t_1 =0.5 minutes
t_2 =2.5 minutes
$T_{F,on}(t_1)$=flue gas temperature measured at time (t_1) from a cold start-up of the system burner determined in accordance with section 3.3 of this Appendix, in degrees Fahrenheit
$T_{F,on}(t_2)$=flue gas temperature measured at the time (t_2) from a cold start-up of the system burner determined in accordance with section 3.3 of this Appendix, in degrees Fahrenheit
$T_{F,SS}$ =as defined in 4.1.4

For vaporizing type oil burners, $\tau_{on}=0$.

4.1.9 Effective gas temperature difference at start-up. Calculate the effective flue gas temperature difference at start-up of the system burner, $\Theta_{F,O,X}$, expressed in degrees Fahrenheit and defined as:

$$\Theta_{F,O,X}=[T_{F,SS}-T_{F,on}(t_1)]\,e^{\frac{t_1}{\tau_{on}}}$$

where:

$T_{F,SS}$ as defined in 4.1.4
$T_{F,on}(t_1)$ as defined in 4.1.8
t_1 as defined in 4.1.8
τ_{on} as defined in 4.1.8

For vaporizing type oil burners, $\Theta_{F,O,X}=0$.

4.1.10 Off-cycle time constant. Calculate the off-cycle time constant, τ_{off}, expressed in minutes and defined as

$$\tau_{OFF}=\frac{t_4-t_3}{\ln\left[\frac{T_{F,OFF}(t_3)-T_{F,OFF}(\infty)}{T_{F,OFF}(t_4)-T_{F,OFF}(\infty)}\right]}$$

where

t_3=1.5 minutes
t_4=9.0 minutes
$T_{F,OFF}(t_3)$=flue gas temperature measured at time (t_3) after shut-down from steady-state operation of the system burner determined in accordance with section 3.2 of this Appendix, in degree Fahrenheit
$T_{F,OFF}(t_4)$=flue gas temperature measured at time (t_4) after shut-down from steady-state operation of the system burner determined in accordance with section 3.2 of this Appendix, in degree Fahrenheit.

4.1.11 Effective flue gas temperature difference at shut-down. Calculate the effective flue gas temperature difference at shut-down of the system burner, $\Psi_{F,O,X}$, expressed in degrees Fahrenheit and defined as:

$$\Psi_{F,O,X}=T_{F,OFF}(t_3)-T_{F,OFF}(\infty)\,e^{\frac{t_3}{\tau_{OFF}}}$$

where

$T_{F,OFF}(t_3)$ as defined in 4.1.10
$T_{F,off}(\infty)$ as defined in 4.1.10
t_3 as defined in 4.1.10
τ_{off} as defined in 4.1.10

4.1.12 Minimum flue gas temperature difference above room temperature. Calculate the minimum flue gas temperature difference above room temperature, $\Psi_{F,\infty,X}$, expressed in Fahrenheit and defined as:

$$\Psi_{F,\infty,X}=T_{F,OFF}(\infty)-70,$$

where

$T_{F,OFF}(\infty)$ as defined in 4.1.10
70 as defined in 4.1.4

4.1.13 Minimum stack gas temperature difference above room temperature. Calculate the minimum stack gas temperature difference above room temperature, $\Psi_{S,\infty,X}$ expressed in degrees Fahrenheit and defined as:

For systems numbered 1-4

$$\Psi_{S,\infty,X}=\frac{(D_F)\,(\Psi_{F,\infty,X})}{(S/_F)\,(D_S)}$$

where

D_F=off-cycle flue gas draft factor selected from Table 1, for units with power burners where D_F is measured, determined in accordance with section 4.4.2 of this Appendix, in degrees Fahrenheit.
D_S=off-cycle stack gas draft factor selected from Table 1, or, for units with power burners where D_F is measured, determined in accordance with section 4.4.3 of this Appendix, in degrees Fahrenheit.
$S/_F$=as defined in 4.1.6
$\Psi_{F,\infty,X}$=as defined in 4.1.52

for systems numbered 5-8:

$$\Psi_{S,\infty,X}=\Psi_{F,\infty,X}$$

where

$\Psi_{F,\infty,X}$ as defined in 4.1.12

4.1.14 Effective stack gas temperature difference at shut-down. Calculate the effective stack gas temperature difference at shut-down, $\Psi_{S,O,X}$ expressed in degrees Fahrenheit and defined as:

for systems numbered 1-4:

$$\Psi_{S,O,X}=\frac{(D_F)\,(\Psi_{F,O,X})}{(S/_F)\,(D_S)}$$

where

D_F as defined in 4.1.13
$\Psi_{F,O,X}$ as defined in 4.1.11
$S/_F$ as defined in 4.1.13
D_S as defined in 4.1.13

for systems numbered 5-8:

$$\Psi_{S,O,X}=\Psi_{F,O,X}$$

where

$\Psi_{F,O,X}$ as defined in 4.1.11

4.1.15 Correction factors for direct vent systems. Calculate a correction factor which corrects for the use of outdoor air for combustion instead of air at room temperature, C_S, defined as

$$C_S=1+\frac{(70-42)\,\eta_{SS}}{(T_{F,SS}-70)\,100}$$

where

42 =average outdoor temperature corresponding to 5200 degree day location, in degrees Fahrenheit
η_{SS} as defined in 4.1.5
T_F as defined in 4.1.4
70 as defined in 4.1.4

The correction factor which corrects for the effect of outdoor air passing through the heat exchanger during the off-period, C'_S, defined as:

$$C'_S=1.22$$

4.1.16 Multiplication factor for sensible heat loss during burner on-cycle. Calculate a multiplication factor for sensible heat loss during burner on-cycle, $K_{S,on}$, defined as:

$$K_{S,on}=\frac{100\;C_P[1+(R_{T,F})\,(A/_F)]}{HHV_A}$$

Where

C_P=0.24 Btu per pound-degree Fahrenheit, specific heat of air as defined in 4.1.2
$R_{T,F}$
$A/_F$=stoichiometric air/fuel ratio determined in accordance with Table 3
HHV_A=average higher heating value of the test fuel determined in accordance with Table 3, in Btu's per pound.

4.1.17 Multiplication factor for sensible heat loss during burner off-cycle. Calculate a multiplication factor for sensible heat loss during burner off-cycle, $K_{S,OFF}$, defined as:

for systems numbered 1-4:

$$K_{S,OFF}=\frac{(T_{F,SS}+460)^{1.19}\,(D_F)\,(K_{S,on})}{(T_{F,SS}-70)^{0.56}}$$

where

460=conversion factor to convert degrees Fahrenheit to degrees Rankine
$T_{F,SS}$ as defined in 4.1.4
70 as defined in 4.1.4
D_F as defined in 4.1.13
$K_{S,on}$ as defined in 4.1.16

for systems numbered 5-8:

$$K_{S,OFF}=\frac{(T_{S,SS}+460)^{1.19}\,(D_S)\,(S/_F)\,(K_{S,on})}{(T_{S,SS}-42)^{0.56}}$$

where

$T_{S,SS}$ as defined in 4.1.7
D_S as defined in 4.1.13
$S/_F$ as defined in 4.1.6
$K_{S,on}$ as defined in 4.1.16
460 as defined in 4.1.17
42 as defined in 4.1.15

for systems numbered 9-12:

$$K_{S,OFF}=\frac{(T_{S,SS}+460)^{1.19}\,(D_F)\,(K_{S,on})}{(T_{S,SS}-42)^{0.56}}$$

where

$T_{S,SS}$ as defined in 4.1.7
D_F as defined in 4.1.13
$K_{S,on}$ as defined in 4.1.16
460 as defined in 4.1.17
42 as defined in 4.1.15

4.1.18 Multiplication factor for infiltration loss during burner on-cycle. Calculate a multiplication factor for infiltration loss during burner on-cycle, $K_{I,on}$, defined as:

for systems numbered 1-18:

$$K_{I,on}=(\Phi)(S/_F)(K_{S,on})$$

where

Φ =0.7 infiltration parameter
$S/_F$ as defined in 4.1.6
$K_{S,on}$ as defined in 4.1.16

4.1.19 Multiplication factor for infiltration loss during burner off-cycle. Calculate a multiplication factor for infiltration loss during burner off-cycle $K_{I,off}$, defined as:

for systems numbered 1-8:

$$K_{I,OFF}=\frac{(T_{S,SS}+460)^{1.19}\,(K_{I,on})\,(D_S)}{T_{S,SS}-42)^{0.56}}$$

where

$T_{S,SS}$ as defined in 4.1.7
460 as defined in 4.1.17
42 as defined in 4.1.15
$K_{I,on}$ as defined in 4.1.18
D_S as defined in 4.1.13

4.1.20 Ratio of average burner on-time per cycle to on-cycle time constant. Calculate the ratio of average burner on-time per cycle to on-cycle time constant, T_{on}/τ_{on}, defined as:

$$\frac{t_{on}}{\tau_{on}}$$

where

t_{on}=3.87 minutes, the average burner on-time per cycle, based on 5 cycles per hour at half load.
τ_{on}=as defined in 4.1.8

4.1.21 Ratio of average burner off-time per cycle to off-cycle time constant. Calculate the ratio of average burner off-time per cycle to off-cycle time constant, T_{off}/τ_{off}, defined as:

$$\frac{t_{off}}{\tau_{off}}$$

where

t_{off}=13.3 minutes, the average burner off-time per cycle, based on 5 cycles per hour at half load.
τ_{off}=as defined in 4.1.10

4.1.22 Effective flue gas temperature difference at burner start-up, corrected for burner cycling effect. Calculate the effective flue gas temperature difference at burner start-up, corrected for burner cycling effect, $\Theta_{F,O}$, expressed in degrees Fahrenheit and defined as: when

$$(t_{on}/\tau_{on})\leq(t_{off}/\tau_{off})$$

for systems numbered 1-8:

$$\Theta_{F,O}=\Theta_{F,O,X}$$

for systems numbered 9-12:

$$\Theta_{F,O}=(C_S)\,(\Theta_{F,O,X})$$

when

$$(t_{on}/\tau_{on})>(t_{off}/\tau_{off});$$

for systems numbered 1-8:

$$\Theta_{F,O}=\Theta_{F,O,X}\left(1-\varepsilon^{-\frac{t_{off}}{\tau_{off}}}\right)$$

for systems numbered 9-12:

$$\Theta_{F,O}=(C_S)\,(\Theta_{F,O,X}\left(1-\varepsilon^{-\frac{t_{off}}{\tau_{off}}}\right)$$

where

t_{on}/τ_{on}) as defined in 4.1.20
t_{off}/τ_{off} as defined in 4.1.21
$\Theta_{F,O,X}$ as defined in 4.1.9
C_S as defined in 4.1.15

4.1.23 Effective flue gas temperature difference at burner shut-down, corrected for burner cycling effect. Calculate the effective flue gas temperature difference at burner shut-down, corrected for burner cycling effect, $\Psi_{F,O}$, when

$$(t_{on}/\tau_{on}\leq(t_{off}/\tau_{off}):$$

for systems numbered 1-8:

$$\Psi_{F,O}=(\Psi_{F,O,X})\left(1-\varepsilon^{-\frac{t_{on}}{\tau_{on}}}\right)$$

for systems numbered 9-12:

$$\Psi_{F,O}=(C'_S)\,(\Psi_{F,O,X})\left(1-\varepsilon^{-\frac{t_{on}}{\tau_{on}}}\right)$$

where

$$(t_{on}/\tau_{on})\;(t_{off}/\tau_{off})$$

for systems numbered 1-8:

$$\Psi_{F,O}=\Psi_{F,O,X}$$

for systems numbered 9-12:

$$\Psi_{F,O}=(C'_S)\,(\Psi_{F,O,X})$$

where
t_{on}/τ_{on} as defined in 4.1.20
t_{off}/τ_{off} as defined in 4.1.21
$\Psi_{F,O,X}$ as defined in 4.1.11
C'_S as defined in 4.1.15

4.1.24 Effective minimum flue gas temperature difference above room temperature, corrected for burner cycling effect. Calculate the effective minimum flue gas temperature difference above room temperature, $\Psi_{F,\infty}$, corrected for burner cycling effect, expressed in degrees Fahrenheit and defined as:

for systems numbered 1-8:

$$\Psi_{F,\infty}=\Psi_{F,\infty,X}$$

for systems numbered 9-12:

$$\Psi_{F,\infty}=(C_S)\,(\Psi_{F,\infty,X})$$

where
C'_S as defined in 4.1.15
$\Psi_{F,\infty,X}$ as defined in 4.1.12

4.1.25 Effective stack gas temperature difference at burner shut-down, corrected for burner cycling effect. Calculate the effective stack gas temperature difference at burner shut-down, corrected for burner cycling effect, $\psi_{S,O}$, expressed in degrees Fahrenheit and defined as:

when

$$(t_{on}/\tau_{on})\leq(t_{off}/\tau_{off})$$

for systems numbered 1-8:

$$\Psi_{S,O}=\Psi_{S,O,X}\left(1-e^{-\frac{t_{on}}{\tau_{on}}}\right)$$

when

$$(t_{on}/\tau_{on})\leq(t_{off}/\tau_{off})$$

For systems numbered 1-8:

$$\psi_{S,O}=\psi_{S,O,X}\left(1-e^{-\frac{t_{on}}{\tau_{on}}}\right)$$

when

$$t_{on}/\tau_{on}>(t_{off}/\tau_{off})$$

for systems numbered 1-8:

$$\Psi_{S,O}=\Psi_{S,O,X}$$

when
t_{on}/τ_{on} as defined in 4.1.20
t_{off}/τ_{off} as defined in 4.1.21
$\Psi_{S,O,X}$ as defined in 4.1.14

4.1.26 Off-cycle sensible heat loss integration factors. For systems numbered 1-4, determine off-cycle sensible heat loss integration factors, *F3* and *F4*, from Figures 3 and 4, respectively, using values of $\Psi_{F,O}$ defined in section 4.2.23, and t_{off}/τ_{off} defined in section 4.1.21.

For systems numbered 5-12, determine, off-cycle sensible heat loss integration factors, *F5* and *F6*, from Figures 5 and 6, respectively, using values of $\Psi_{F,O}$ defined in section 4.1.23, and t_{off}/τ_{off} defined in section 4.1.21.

4.1.27 Off-cycle infiltration heat loss integration factors. For systems numbered 1-8, determined off-cycle infiltration heat loss integration factors, *F7* and *F8*, from Figures 7 and 8, respectively, using values of $\Psi_{S,O}$ defined in section 4.1.25, and t_{off}/τ_{off} defined in section 4.1.21.

4.1.28 On-cycle sensible heat loss. Calculate the on-cycle sensible heat loss of the system, $L_{S,ON}$, expressed in percent and defined:

for systems numbered 1-8:

$$L_{S,ON}=L_{S,SS}-(K_{S,ON})\,(\Theta_{F,O})\left(\frac{1}{t_{on}/\tau_{on}}\right)\left(1-e^{-\frac{t_{on}}{\tau_{on}}}\right),$$

for systems numbered 9-12:

$$L_{S,ON}=(C_S)\,(L_{S,SS,A})-(K_{S,ON})\,(\Theta_{F,O})\left(\frac{1}{t_{on}/\tau_{on}}\right)\left(1-e^{-\frac{t_{on}}{\tau_{on}}}\right)$$

where
C_S as defined in 4.1.15
$L_{S,SS,A}$ as defined in 4.1.4
$K_{S,ON}$ as defined in 4.1.16
$\Theta_{F,O}$ as defined in 4.1.22
t_{on}/τ_{on} as defined in 4.1.20

4.1.29 Off-cycle sensible heat loss. Calculate the off-cycle sensible heat loss of the system, $L_{S,OFF}$, expressed in percent and defined as:

for systems numbered 1-4:

$$L_{S,OFF}=(K_{S,OFF})\left(\frac{t_{off}}{t_{on}}\right)(F3)+(\Psi_{F,\infty})\,(F4),$$

for systems numbered 5-12:

$$L_{S,OFF}=(K_{S,OFF})\left(\frac{t_{off}}{t_{on}}\right)(F5)+(\Psi_{F,\infty})\,(F6),$$

where
$K_{S,OFF}$ as defined in 4.1.17
t_{off} as defined in 4.1.21
t_{on} as defined in 4.1.20
F3, *F4*, *F5*, and *F6* as defined in 4.1.26
$\psi_{F,\infty}$ as defined in 4.1.24

4.1.30 On-cycle infiltration heat loss. Calculate the on-cycle infiltration heat loss of the system, $L_{I,ON}$, expressed in percent and defined as:

for systems numbered 1-8:

$$L_{I,ON}=K_{I,ON}\,(70-42),$$

where
$K_{I,ON}$ as defined in 4.1.18
70 as defined in 4.1.4
42 as defined in 4.1.15

for systems numbered 9-12:

$$L_{I,ON}=0$$

4.1.31 Off-cycle infiltration heat loss. Calculate the off-cycle infiltration heat loss of the system $L_{I,OFF}$, expressed in percent and defined as:

for systems numbered 1-8:

$$L_{I,OFF}=K_{I,OFF}\,(70-42)\left(\frac{t_{off}}{t_{on}}\right)(F7)+(\Psi_{S,\infty,X})\,(F8)$$

where
$K_{I,OFF}$ as defined in 4.1.19
70 as defined in 4.1.4
42 as defined in 4.1.15
t_{off} as defined in 4.1.21
t_{on} as defined in 4.1.27
F7, *F8* as defined in 4.1.27
$\Psi_{S,\infty,X}$ as defined in 4.1.13

for systems numbered 9-12:

$$L_{I,OFF}=0$$

4.1.32 Part-load fuel utilization efficiency. Calculate the part-load fuel utilization efficiency, expressed in percent and defined as:

for indoor units—

$$\eta_u=100-L_{L,A}-\left[\frac{t_{on}}{t_{on}+\frac{Q_P}{Q_{in}}\,(t_{off})}\right]\times[L_{S,ON}+L_{S,OFF}+L_{I,ON}+L_{I,OFF}],$$

for vented floor furnaces

$$\eta_u=100-L_{L,A}-C_i(L_i)-\left[\frac{t_{on}}{t_{on}+\left(\frac{Q_P}{Q_{in}}\right)(t_{off})}\right]\times[L_{S,ON}+L_{S,OFF}+L_{I,ON}+L_{I,OFF}]$$

where
C_i =3.3 for vented floor furnaces
Q_P =pilot flame fuel input rate determined in accordance with section 3.2 of this Appendix, in Btu's per hour
Q_{IN} =full-load input rate (including pilot flame fuel input rate) determined in accordance with section 3.1 of this Appendix, in Btu's per hour
L_i =jacket loss determined in accordance with section 3.4 of this Appendix, in percent
$L_{L,A}$ as defined in 4.1.5
t_{on} as defined in 4.1.20
t_{off} as defined in 4.1.21
$L_{S,ON}$ as defined in 4.1.28
$L_{S,OFF}$ as defined in 4.1.29
$L_{I,ON}$ as defined in 4.1.30
$L_{I,OFF}$ as defined in 4.1.31

4.1.33 Annual fuel utilization efficiency. Calculate the annual fuel utilization efficiency, $EFFY_A$, defined as: where

$$EFFY_A=\frac{(\eta_{SS})\,(\eta_u)\,(5200)}{(\eta_{SS})\,(5200)+(2.5)\,(\eta_u)\left(\frac{Q_P}{Q_{in}}\right)(1.7)\,(4600)}$$

where
5200=the average number of annual heating degree days for the United States
4600=the average number of non heating season hours per year that the energy to the pilot light is assumed wasted
1.7 =average vented heater sizing factor
η_{SS} =as defined in 4.1.5
η_u =as defined in 4.1.32
Q_P =as defined in 4.1.32
Q_{IN} =as defined in 4.1.32

4.2 *Additional Requirements for Vented Home Heating Equipment Utilizing a Stack (or Flue) Damper.* Calculate the stack (or flue) damper effectiveness, D_o, defined as:

when $A_D\cos\Omega>0.59\,A_S$:

$$D_o=\frac{2.24\left[1-\frac{A_D\cos\Omega}{A_S}\right]}{\sqrt{1-\left[1-\frac{A_D\cos\Omega}{A_S}\right]^2}}$$

when $A_D\cos\Omega\leq 0.59\,A_S$:
$D_O=1$,
where
A_S=cross sectional area of the stack determined in accordance with section 3.5 of this Appendix, in square inches
A_D=net area of the damper plate determined in accordance with section 3.5 of this Appendix, in square inches
Ω=the angle the damper plate makes when closed with a plane perpendicular to the axis of the stack

4.3 *Additional Requirements for Vented Home Heating Equipment Utilizing Indoor Air for Combustion and Draft Control.* For units obtaining combustion air and draft control air from inside the residence, the appropriate factor describing the ration of on-cycle stack flow to on-cycle flue flow (S/F), the ratio of off-cycle flue flow to on-cycle flue flow at identical temperatures (D_P), and the ratio of off-cycle stack flow to on-cycle stack flow at iedntical temperatures (D_S) shall be determined from Table 2.

4.3.1 Optional procedure for determination of D_P for vented home heating equipment employing a power burner. Calculate the ration (D_P) of the rate of flue gas mass flow through the vented heater during the off period, $m_{F,OFF}$ ($T_{F,SS}$), to the rate of flue gas mass flow

during the on-period, $m_{F,SS}$ ($T_{F,SS}$), and defined as:

$$D_P=\frac{\dot{m}_{F,OFF}\,(T_{F,SS})}{\dot{m}_{F,SS}\,(T_{F,SS})},$$

where

$$m_{F,OFF}\,(T_{F,SS})=m_{F,OFF}\,(T_{F,OFF})\times\left[\frac{T_{F,SS}-42}{T_{F,OFF}-42}\right]^{0.56}\left[\frac{T_{F,OFF}+460}{T_{F,SS}+460}\right]^{1.19}$$

where
$T_{F,SS}$ as defined in 4.1.4
$T_{F,OFF}$=flue gas temperature during the off-period measured in accordance with section 3.6 of this Appendix, in degrees Fahrenheit

$$\dot{m}_{F,OFF}\,(T_{F,OFF})=\frac{100\dot{V}_T}{C_T}\,q_F,$$

where
V_T=flow rate of tracer gas through the vented heater measured in accordance with section 3.6 of this Appendix, in cubic feet per minute
C_T=concentration by volume of tracer gas present in the flue gas sample measured in accordance with section 3.6 of this Appendix, in percent

$$q_F=\frac{1.325\,P_B}{460+T_{F,OFF}}$$

where
$T_{F,OFF}$ as defined above
P_B =barometric pressure measured in accordance with section 3.6 of this Appendix, in inches of mercury

$$m_{F,SS}\,(T_{F,SS})=\left[(R_{T,F})\,\frac{A}{F}+1\right]\frac{Q_{in}}{HHV_A},$$

where
$R_{T,F}$ as defined in 4.1.2
A/F as defined in 4.1.16
Q_{in} as defined in 4.1.32
HHV_A as defined in 4.1.16

4.3.2 Optional procedure for determination of off-cycle draft factor for flue gas flow for vented home heating equipment employing a power burner. Calculate the off-cycle draft factor for flue gas flow, D_F, defined as:

for systems numbered 2, 4, or 10: $D_F=(D_P)$

for system number 12: $D_F=(D_P)\,(D_o)$,

where
D_P as defined in 4.3.1
D_o as defined in 4.2

4.3.3 Optional procedure for determination of off-cycle draft factor for stack gas flow for vented home heating equipment employing a power burner. Calculate the off-cycle draft factor for stack gas flow, D_S, defined as:

for system number 2: $D_S=D_P=0.55$

for system number 4: $D_S=D_P=.40$

for system number 8: $D_S=(D_P)\,(D_o)$

where
D_P as defined in 4.3.1
D_s as defined in 4.2

4.4 *Additional Requirements for Vented Home Heating Equipment Utilizing a Direct Vent System.* For vented heaters utilizing a direct vent system or intended for outdoor installation, the appropriate S/F factor and D_P factor shall be determined from Table 2. If a unit is equipped with a power burner, D_P, may be calculated using the value of D_P determined in section 4.3.1 of this section.

4.5 *Additional Requirements for Vented Home Heating Equipment which Modulate or Vary Fuel Input without Controlling Excess Combustion Air.* A vented heater which is equipped with a mechanism for reducing the rate of fuel input but does not provide a means for controlling excess combustion air, shall be tested at its maximum firing rate in accordance with test procedures in section 3. These test results shall be used to calculate a seasonal efficiency and an annual operating cost which is based upon a single fixed fuel input rate.

4.6 *National Average Number of Burner Operating Hours.* Calculate the average number of burner operating hours, BOH, defined as:

$BOH = (A)\ (2080)\ (\text{design heating requirement}) - B$,

where
2080 = national average annual heating load hours design heating requirement

$$= \frac{(Q_{in})(0.5)}{1000}$$

0.5 = approximate value for the ratio of steady state efficiency to 100 times the average heater sizing factor.
1000 = conversion factor to convert Btu's per hour to kilo-Btu's per hour
Q_{IN} = as defined in 4.1.32

$$A = \frac{100{,}000}{(341{,}300)\ (PE + yBE) + (Q_{in} - Q_P)\ \eta_s}$$

$B = (0.0416)\ (Q_P)\ (\eta_s)\ (A)$
PE = power burner electrical energy input rate at full-load steady-state operation determined in accordance with section 3.1 of this Appendix, in kilowatts.
BE = circulating-air blower (or circulating water pump electrical energy input rate at full-load steady-state operation determined in accordance with section 3.1 of this Appendix, in kilowatts
y = 1.00 for vented heaters employing a single motor to drive a power burner and air circulating fan or blower, (i.e., the ratio of average blower or pump on-time to average burner on-time) and 1.38 for all other vented heaters.
Q_{IN} = as defined in 4.1.32
Q_P = as defined in 4.1.32
η_s = as defined in 4.1.32

4.7 *Average Annual Fuel Energy Consumption for Vented Home Heating Equipment.* Calculate the average annual fuel energy consumption for vented heaters, E_F, expressed in Btu's per year, and defined as:

$$E_F = (Q - Q_{INP})\ (BOH) + (8760)\ (Q_P),$$

where
Q_{IN} as defined in 4.1.32
Q_P as defined in 4.1.32
BOH as defined in 4.6
8760 as defined in 4.1.33

4.8 *Average Annual Auxiliary Electrical Energy Consumption for Vented Home Heating Equipment.* Calculate the average annual auxiliary electrical energy consumption, E_{AE}, expressed in kilowatt-hours per year and defined as:

$$E_{AE} = (PE + y\ BE)\ (BOH)$$

where
PE as defined in 4.6
BE as defined in 4.6
y as defined in 4.6
BOH as defined in 4.6

4.9 *Average Number of Burner Operating Hours in Different Geographic Regions of the United States.* Calculate the average number of burner operating hours by geographic region of the United States, BOH_R, defined as:

$BOH_R = (A)\ (HLH)\ (\text{design heating requirement}) - B$,

where
A as defined in 4.6
HLH = heating load hours for a specific geographic region determined in accordance with the heating load hour map in Figure 9
Design heating requirement = as defined in 4.6

$$B = \frac{(2)(HLH)(A)(Q_P)(\eta_s)}{100{,}000},$$

where
100,000 = Factor that accounts for percent and KBTU.
(2) = ratio of average length of heating season to heating load hours.
HLH = as defined above
A as defined in 4.6
Q_P as defined in 4.1.32
η_s as defined in 4.1.32

4.10 *Average Annual Fuel Energy Consumption for Vented Home Heating Equipment by Geographic Region of the United States.* Calculate the average annual fuel energy consumption by geographic region of the United States, $E_{F,\ R}$, expressed in Btu's per year, and defined as:

$$E_{F,\ R} = (Q_{IN} - Q_P)\ (BOH_R) + (8760)\ (Q_P),$$

where
Q_{in} as defined in 4.1.32
Q_P as defined in 4.1.32
BOH_R as defined in 4.9
8760 as defined in 4.1.33

4.11 *Average Annual Auxiliary Electrical Energy Consumption for Vented Home Heating Equipment in Different Geographic Regions of the United States.* Calculate the average annual auxiliary electrical energy consumption for different geographic regions of the United States, $E_{AE,\ R}$, expressed in kilowatt-hours per year and defined as:

$$E_{AE,\ R} = (PE + y\ BE)\ (BOH_R),$$

where
PE as defined in 4.6
BE as defined in 4.6
Y as defined in 4.6
BOH_R as defined in 4.9

4.12. *Minimum Standardized Design Heating Requirement.* Calculate the minimum standardized design heating requirement, DHR_{MIN}, expressed in Btu's per-hour for which a regional annual operating cost could be computed, defined as:

$$DHR_{MIN} = \frac{(\eta_{ss})\ (Q_{in})}{200}$$

4.13 *Maximum Standardized Design Heating Requirement.* Calculate the maximum standardized design heating requirement, DHR_{MAX}, expressed in Btu's per-hour, for which a regional annual operating cost could be computed, defined as:

$$DHR_{MAX} = \frac{(\eta_{ss})\ (Q_{in})}{110}$$

4.14 *Average Number of Burner Operating Hours by Geographic Region of the United States for the Minimum Standardized Design Heating Requirement.* Calculate the average number of burner operating hours by geographic region of the United States for the minimum standardized design heating requirement, $BOH_{R\text{-}MIN}$, defined as:

$$BOH_{R\text{-}MIN} = A(HLH)\ (DHR_{MIN}) - B$$

where
A as defined in 4.6.
HLH as defined in 4.9
DHR_{MIN} as defined in 4.12
B as denfied in 4.9

4.15 *Average Number of Burner Operating Hours by Geographic Region of the United States for the Maximum Standardized Design Heating Requirement.* Calculate the average number of burner operating hours by geographic region of the United States for the maximum standardized design heating requirement, $BOH_{R\text{-}MAX}$, defined as:

$$BOH_{R\text{-}MAX} = A(HLH)\ (DHR_{MAX}) - B,$$

where
A as defined in 4.6
HLH as defined in 4.9
DHR_{MAX} as defined in 4.13
B as defined in 4.9

4.16 *Average Annual Fuel Energy Consumption for Vented Home Heating Equipment by Geographic Region of the United States for the Minimum Standardized Design Heating Requirement.* Calculate the average annual fuel energy consumption by geographic region of the United States for the minimum standardized design heating requirement, $E_{F,\ R\text{-}MIN}$ expressed in Btu's per year and defined as:

$$E_{R,\ R\text{-}MIN} = (Q_{in} - Q_P)\ (BOH_{R\text{-}MIN}) + (8760)\ (Q_P),$$

where
Q_{in} as defined in 4.1.32
Q_P as defined in 4.1.32
$BOH_{R\text{-}MIN}$ as defined in 4.14
8760 as defined in 4.1.33

4.17 *Average Annual Fuel Energy Consumption for Vented Home Heating Equipment by Geographic Region of the United States for the Maximum Standardized Design Heating Requirement.* Calculate the average annual fuel energy consumption by geographic region of the United States for the maximum design heating requirement, $E_{F,\ R\text{-}MAX}$ expressed in Btu's per year and defined as:

$$E_{F,\ R\text{-}MAX} = (Q_{IN} - Q_P)\ (BOH_{R\text{-}MAX}) + (8760)\ (Q_P),$$

where
Q_{IN} as defined in 4.1.32
Q_P as defined in 4.1.32
$BOH_{R\text{-}MAX}$ as defined in 4.15
8760 as defined in 4.1.33

4.18 *Average Annual Auxiliary Electrical Energy Consumption for Vent Home Heating Equipment by Geographic Region of the Minimum Standardized Design Heating Requirement.* Calculate the average annual auxiliary electrical energy consumption by geographic region of the United States for the minimum standardized design heating requirement, $E_{AE,\ R\text{-}MIN}$, expressed in kilowatt-hours per year and defined as:

$$E_{AE,\ R\text{-}MIN} = (PE + y\ BE)\ (BOH_{R\text{-}MIN}),$$

where
PE as defined in 4.6
Y as defined in 4.6
BE as defined in 4.6
$BOH_{R\text{-}MIN}$ as defined in 4.9

4.19 *Average Annual Auxiliary Electrical Energy Consumption for Vented Home Heating Equipment by Geographic Region of the United States for the Maximum Standardized Design Heating Requirement.* Calculate the average annual auxiliary electrical energy consumption by geographic region of the United States for the maximum standardized design heating requirement, $E_{AE,\ R-MAX} = (PE + y\ BE)\ (BOH_{R-MAX})$,
where
PE as defined in 4.6
y as defined in 4.6
BE as defined in 4.6
$BOH_{R\text{-}MAX}$ as defined in 4.15

TABLE 1.—*Factors describing air flow rate for gas and oil-fueled vented home heating equipment utilizing indoor air for combustion and draft control*

Type of Burner	Units without a stack damper but with								Units with a stack damper and							
	Integral draft diverter				Barometric draft regulator				Integral draft diverter				Barometric draft regulator			
	System No.	*S/F*	D_F	D_S	System No.	*S/F*	D_F	D_S	System No.	*S/F*	D_F	D_S	System No.	*S/F*	D_F	D_S
Vaporizing	1	2.4	1.0	1.0	3	1.4	1.0	1.0	5	2.4	.....	D_o	7	1.4	.....	D_o
Power	2	2.4	.3	.85	4	1.4	.30	.70	6	2.4	.....	D_o	8	1.4	.....	0.30 X

NOTE.—The above factors were developed by the National Bureau of Standards and are based upon information in the public literature, laboratory and computer simulation studies conducted at NBS, and laboratory and field data obtained by several research firms under contract to NBS and FEA.

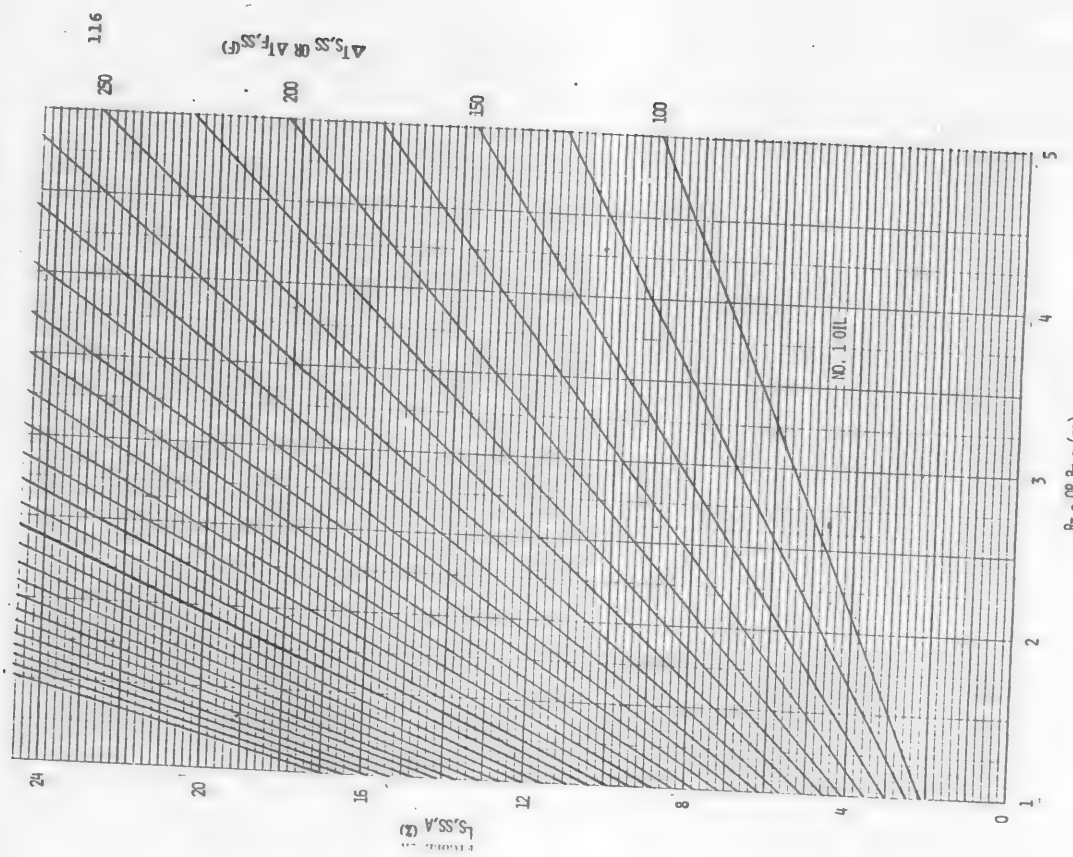
TABLE 2.—*Factors describing air flow rates for Gas or oil-fueled vented floor furnaces or home heating equipment with a direct vent system*

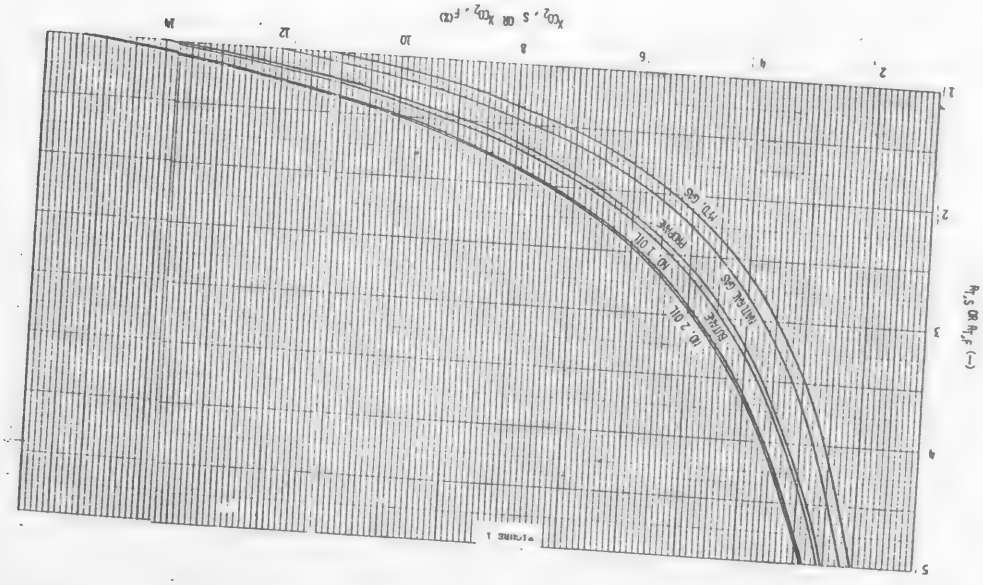
Type of burner	Units without a stack or flue damper		Outdoor units with a flue damper or indoor units with a stack damper		Type of draft	*S/F*
	System No.	D_F	System No.	D_F		
Vaporizing	9	1.00	11	D_o	None	1
Power	10	.30	12	0.30xD_o	Barometric draft regulator	1.4
					Integral draft diverter	2.4

NOTE.—The above factors were developed by the National Bureau of Standards and are based upon information in the public literature, laboratory and computer simulation studies conducted at NBS, and laboratory and field data obtained by several research firms under contract to NBS and FEA.

TABLE 3.—*Values of higher heating value (HHV), Stoichiometric air/fuel ratio (A/F), and latent heat loss ($L_{L,A}$) for typical fuels*

Fuels	HHV_A (British thermal unit per pound)	*A/F*(..)	$L_{L,A}$ (percent)
No. 1 oil	19,800	14.58	6.55
No. 2 oil	19,500	14.51	6.50
Natural gas	21,800	16.04	9.91
Manufactured gas	18,500	11.83	10.16
Propane	21,500	15.60	8.00
Butane	21,300	15.38	7.30


NO. 1 OIL
$R_{T,S}$ OR $R_{T,F}$ (—)
$T_{S,SS,A}$ (°F)
$\Delta T_{S,SS}$ OR $\Delta T_{F,SS}$ (°F)


NO. 2 OIL
DIESEL
NO. 1 OIL
PROPANE
MIDRANGE GAS
PUR GAS
$R_{T,S}$ OR $R_{T,F}$ (—)
$\chi_{CO_2,S}$ OR $\chi_{CO_2,F}$ (%)

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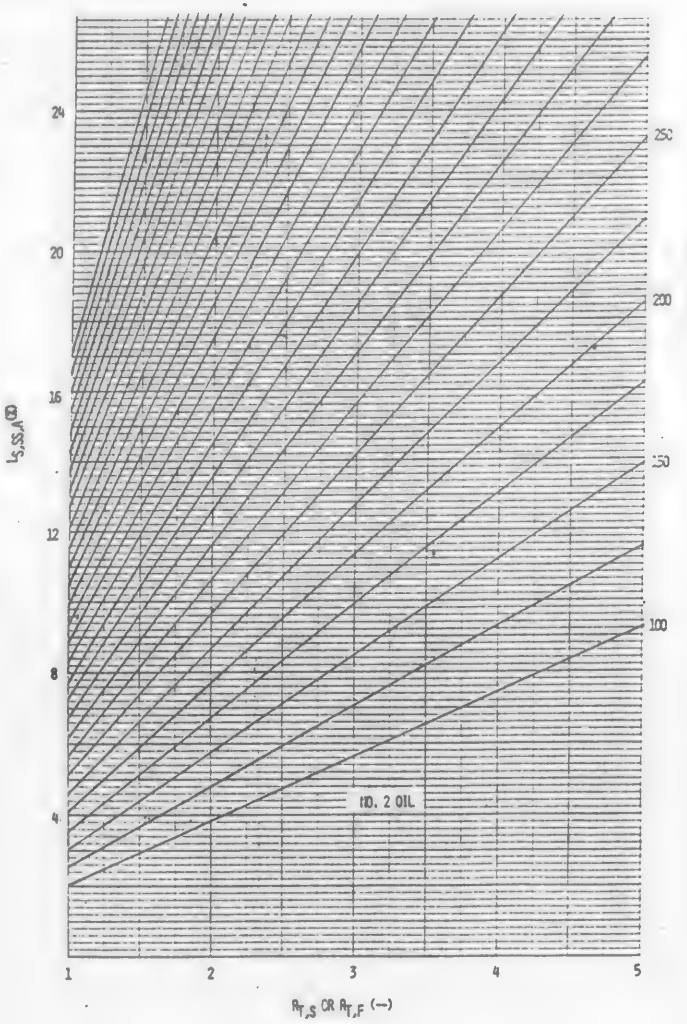

FIGURE 2B

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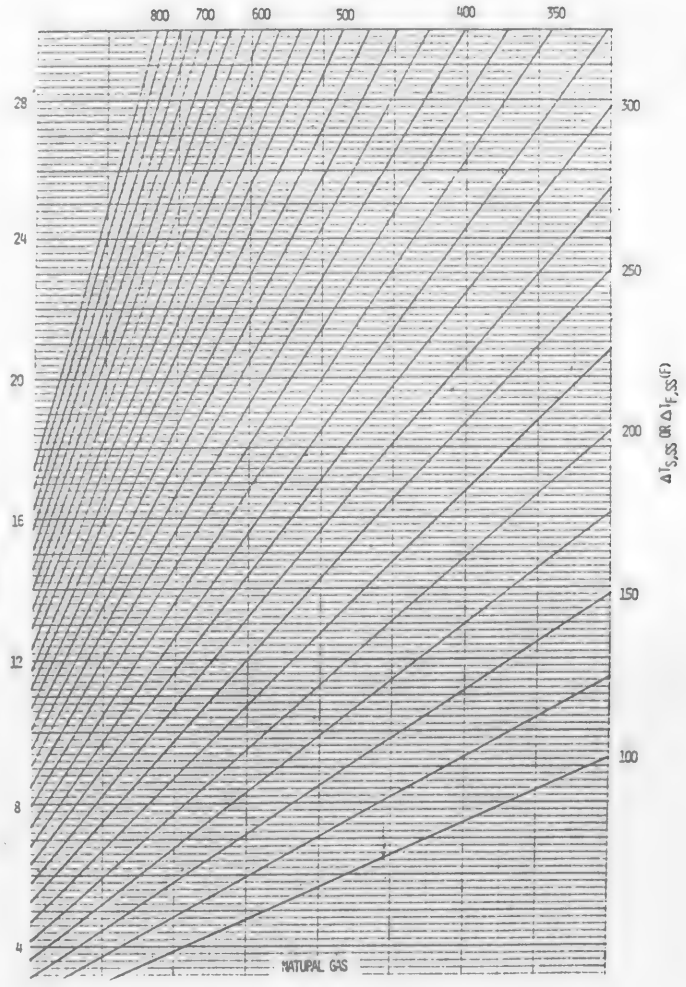
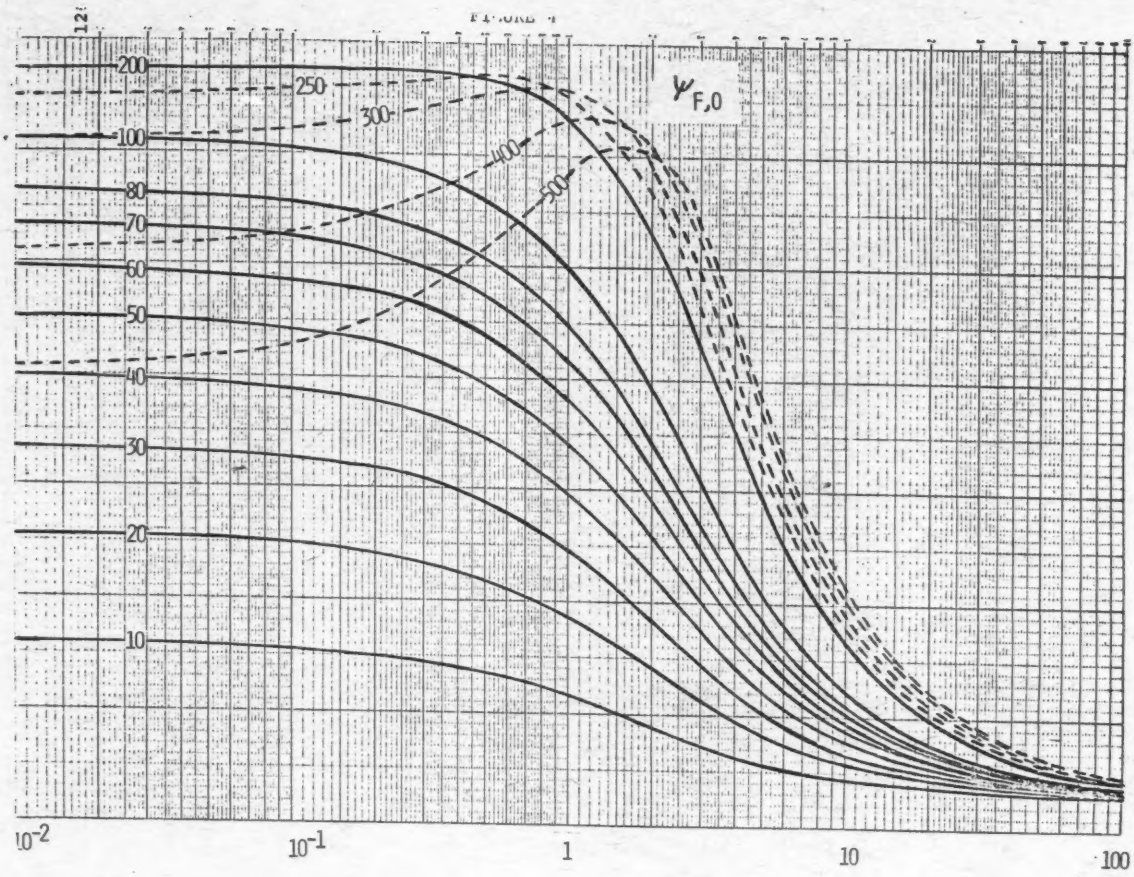


FIGURE 2C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300
400
500
100
80
70
60
50
40
30
20
10
10^{-2}
10^{-1}
1
10
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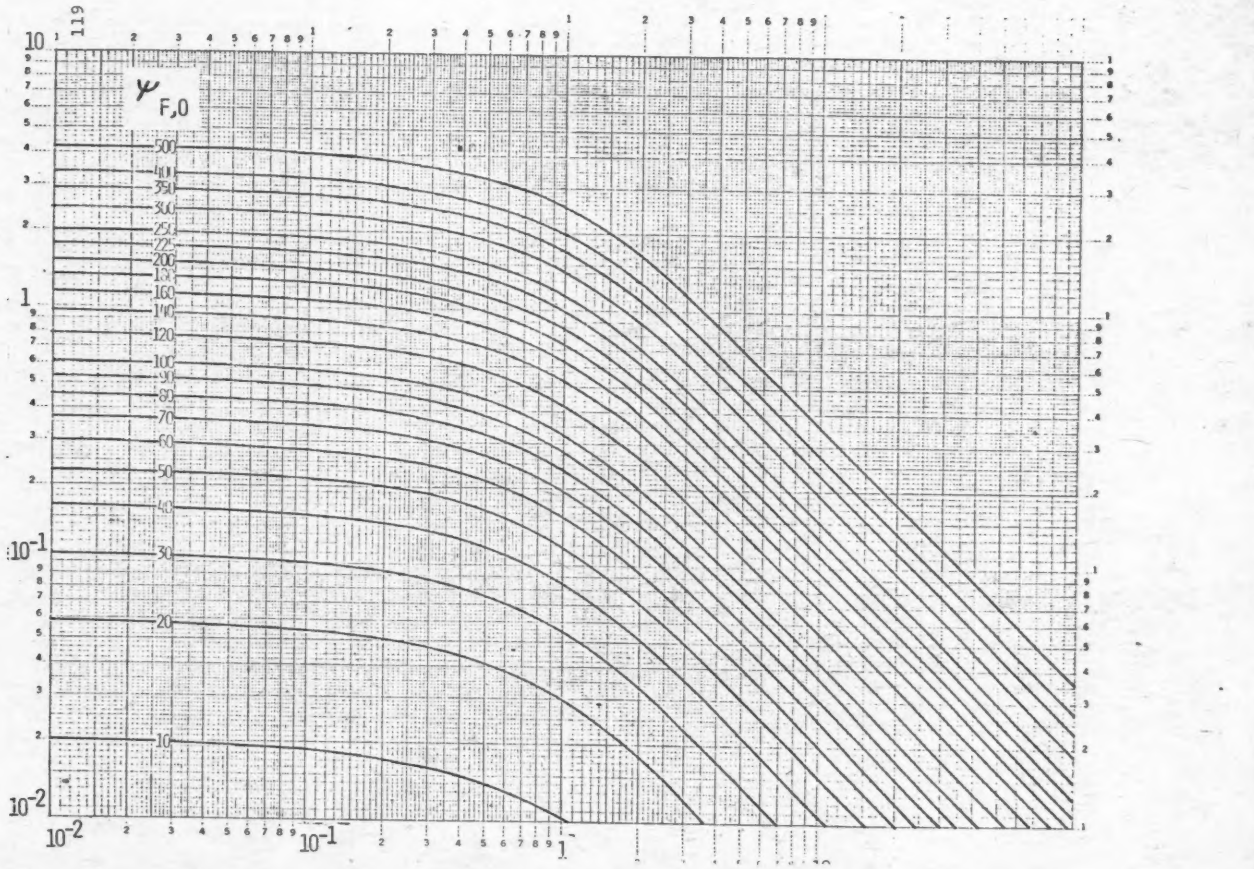
$\psi_{F,0}$
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120
100
90
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50
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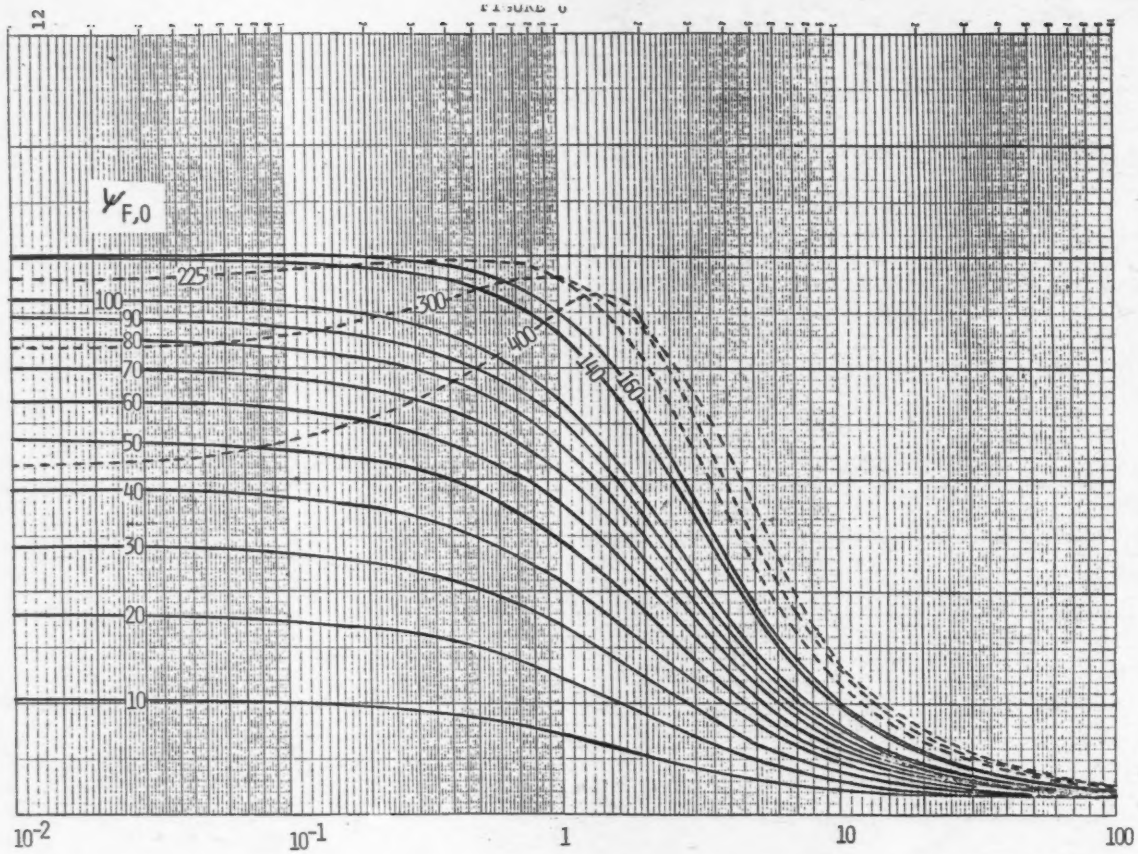
20
10
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1


$\Psi_{F,0}$
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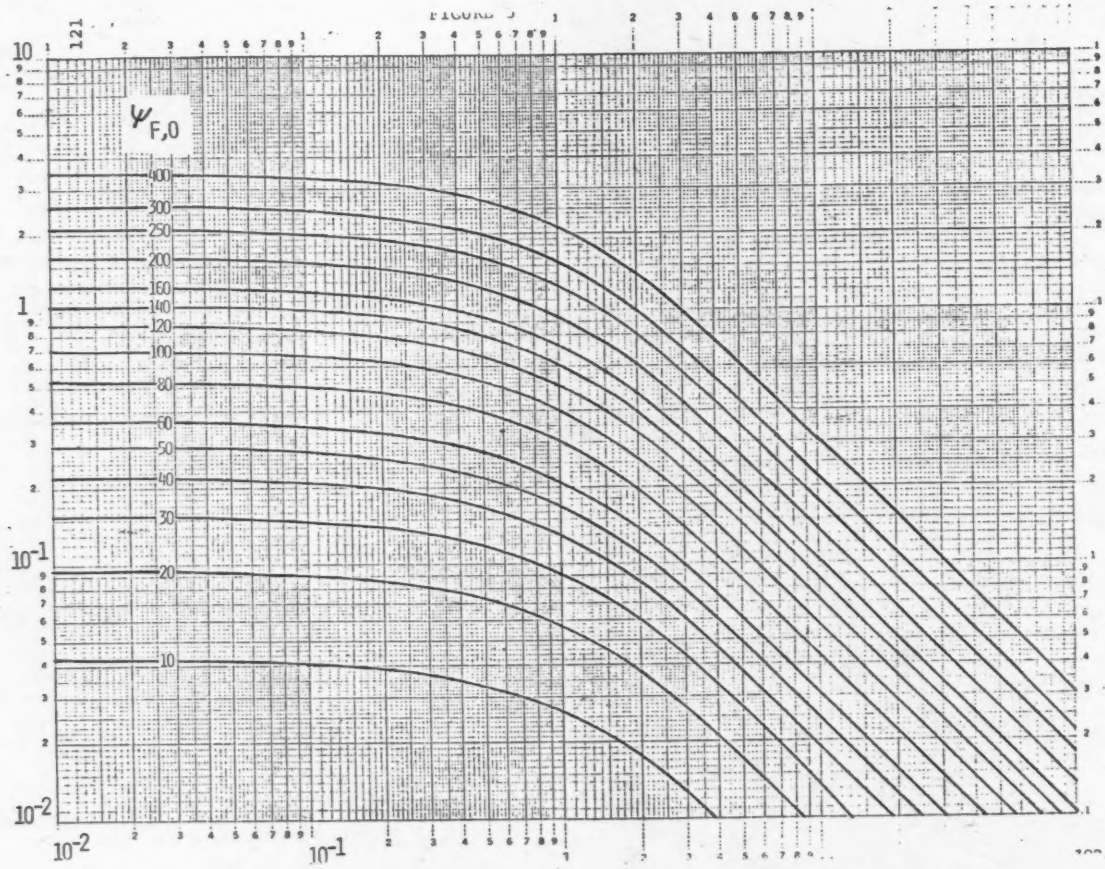
10^{-1}
1
10
100


$\Psi_{F,0}$
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300
250
200
160
140
120
100
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60
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20
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}

FIGURE 8

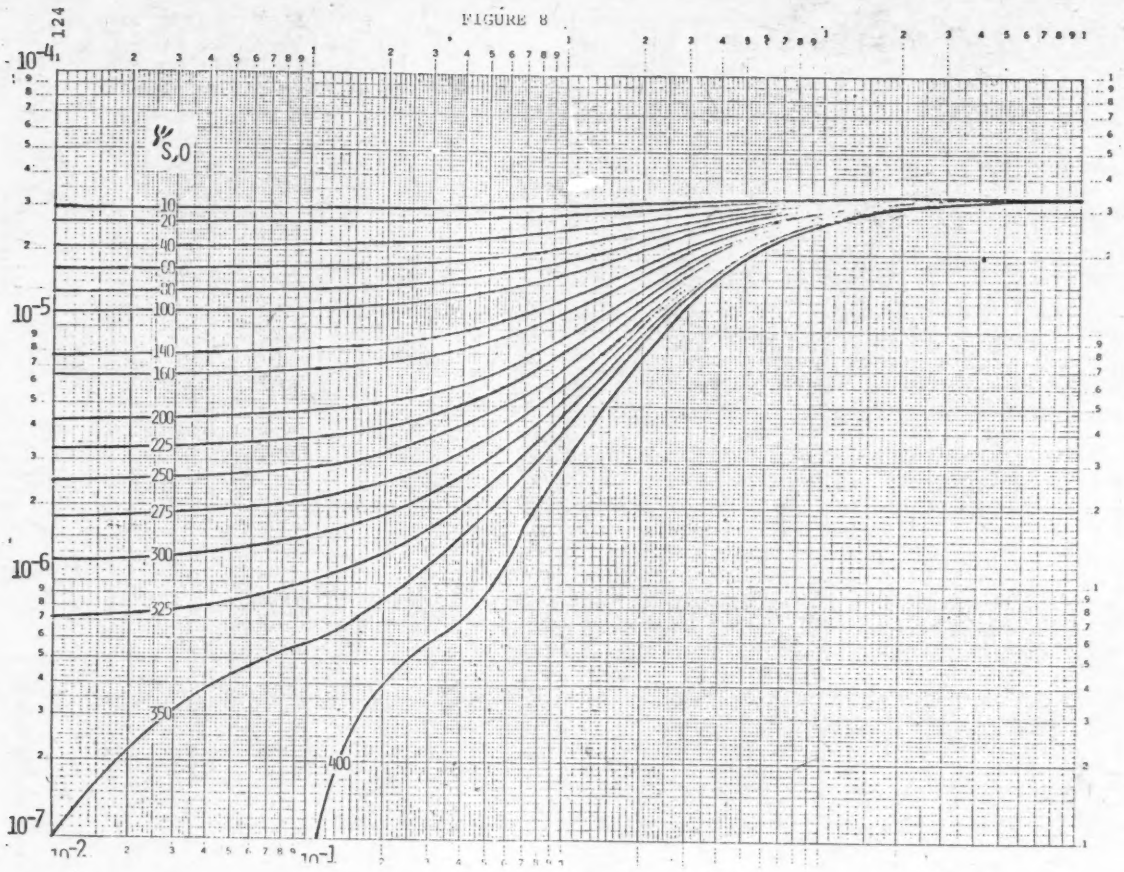


FIGURE 7

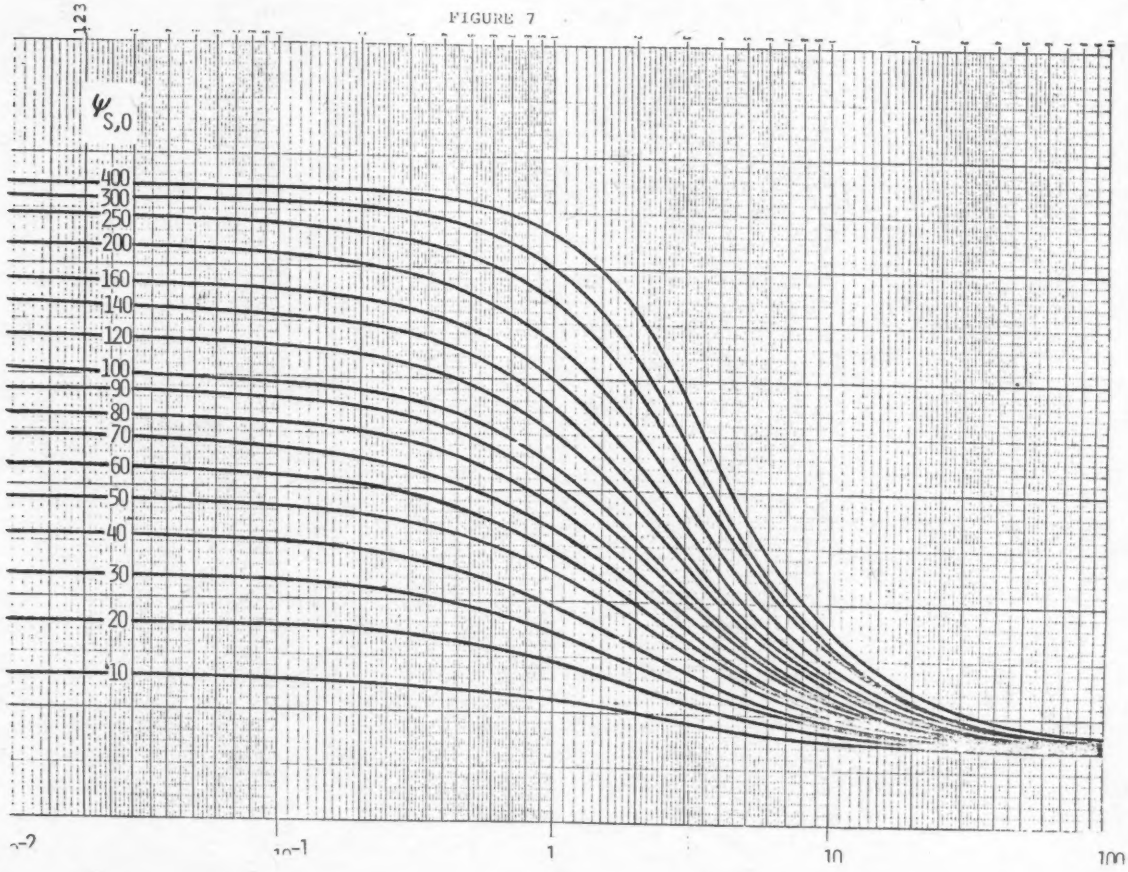
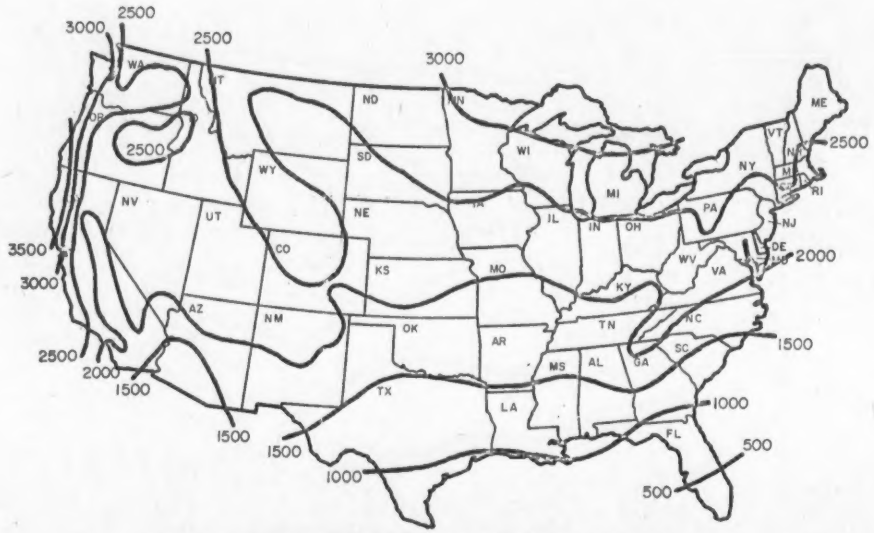


FIGURE 9



This map is reasonably accurate for most parts of the United States but is necessarily highly generalized, and consequently not too accurate in mountainous regions, particularly in the Rockies.

FIGURE 10

WORK SHEET FOR FURNACE/BOILER SYSTEM

Measured Quantities and System Characteristic Constants

1	2	3	4	5	6	7	8
SYS# (-)	TFUEL (-)	HHV Btu/lb.	Q_{IN} Btu/hr.	Q_P Btu/hr.	PE kW	BE kW	$\chi_{CO_2,S}$ %

9	10	11	12	13	14	15	16
$T_{S,SS,X}$ F	$\chi_{CC_2,F}$ %	$T_{F,SS}$ F	$T_{F,ON}(t_1)$ F	$T_{F,ON}(t_2)$ F	$T_{F,OFF}(t_3)$ F	$T_{F,OFF}(t_4)$ F	$T_{F,OFF}(\infty)$ F

17	18	19	20	21	22
L_J (-)	S/F (-)	D_F (-)	D_S (-)	ϕ (-)	α (-)

Derived System Parameters

23	24	25	26	27	28	29	30
PF (-)	HHV_A Btu/lb.	A/F (-)	$L_{L,A}$ %	L_L %	$R_{T,F}$ (-)	$L_{S,SS}$ %	η_{SS} %

31	32	33	34	35	36	37	38
$T_{S,SS}$ F	τ_{ON} minutes	$\upsilon_{F,O,X}$ F	τ_{OFF} minutes	$\Psi_{F,O,X}$ F	$\Psi_{F,\infty,X}$ F	$\Psi_{S,\infty,X}$ F	$\Psi_{S,O,X}$ F

39	40	41	42	43
C_S (-)	$K_{S,ON}$ (%)/F	$K_{S,OFF}$ (%)/R 0.37	$K_{I,ON}$ (%)/F	$K_{I,OFF}$ (%)/R 0.37

Calculation of System Losses and Annual Fuel Utilization Efficiency

44	45	46	47	48	49	50	51
T_{OA} F	t_{ON} minutes	t_{OFF} minutes	t_{ON}/τ_{ON} (-)	t_{OFF}/τ_{OFF} (-)	$\theta_{F,O}$ F	$\Psi_{F,O}$ F	$\Psi_{F,\infty}$ F

52	53	54	55	56	57	58	59
$\Psi_{S,O}$ F	$\Psi_{S,\infty}$ F	F3 $R^{0.37}$	F4 $R^{-0.63}$	F5 $R^{0.37}$	F6 $R^{-0.63}$	F7 $R^{-0.63}$	F8 $R^{-1.63}$

60	61	62	63	64	65	66	67
$L_{S,ON}$ %	$L_{S,OFF}$ %	$L_{I,ON}$ %	$L_{I,OFF}$ %	η_u %	DD °F-days	HR hours	$EFFY_A$ %

[FR Doc.77-24955 Filed 8-30-77;8:45 am]